AN ANALYSIS OF THE JACK FAUCETT ASSOCIATES AUTOMOBILE SECTOR FORECASTING MODEL

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The general research design was developed by Barbara C. Richardson and Kent B. Joscelyn, the co-principal investigators of the project. Kent B. Joscelyn supervised the general direction of the study. Barbara C. Richardson provided day-to-day supervision and participated in developing the framework for the model analysis. Daniel B. Suits provided analytical guidance. W. Steven Barnett, Gerald L. Musgrave, David C. Roberts, Prakash B. Sanghvi, and Lawrence D. Segel further developed and implemented the specific technical approach of this study.

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Kent B. Joscelyn
Co-principal Investigator

Barbara C. Richardson
Co-principal Investigator

EXECUTIVE SUMMARY

This document reports the results of an analysis of the Jack Faucett Associates Automobile Sector Forecasting Model. The analysis, performed by the Policy Analysis Division of the Highway Safety Research Institute (HSRI) of The University of Michigan, was sponsored by the Motor Vehicle Manufacturers Association and is part of a larger HSRI study entitled "Analytical Study of Mathematical Models of the Motor Vehicle System."

The Faucett model is an econometric stock-adjustment long-term automobile sector forecasting model. The model is relatively small, and is designed to forecast the effects of such policies as fuel economy standards, gasoline taxes, and excise taxes and rebates on: gasoline consumption, vehicle miles traveled (VMT), new-car prices and sales, the number of cars in use (by size and age), and fuel economy. These forecasts are generated by the model given a proposed policy, in the context of projected technological cost relationships, demographic trends, and economic conditions.

The HSRI analysis is based primarily on documentation for the original version of the model and a computer-programmed version received in August 1977. Three additional versions were received in February 1979, but have essentially the same model structure, and this report's findings generally apply to the revised versions as well. The computer program contains a number of typographical and programming errors (some corrected in later versions) so that the program generates the output of a slightly distorted version of the Faucett model.

The HSRI analysis of the model consisted of four tasks dealing with: model structure, algorithm and equation structure, forecasting behavior, and model sensitivity.

In the model structure task the theory and logic underlying the model were investigated. The Faucett model was a pioneering attempt to model manufacturers' responses to government policy alternatives given technological fuel-economy cost trade-offs by simulating the changing size and composition of the U.S. automobile stock. The model consists of a supply side, called the Industry/Policy Block, and a demand side containing all of the econometric equations, called the Demand Block. The HSRI staff found a major weakness of the model structure to be limitations imposed by basic assumptions in the Industry/Policy Block, particularly the assumptions that manufacturers minimize vehicle ownership costs to the consumer and that the proportion of each size class produced by each manufacturer is constant. As a result of the latter assumption the model cannot be relied upon to produce a reasonable measure of corporate average fuel economy (CAFE).

Equation structure was studied by reestimating the model's econometric equations and checking the reestimated coefficients against those reported by the authors. The regression statistics were also evaluated. The HSRI staff successfully reproduced all but one of the six econometric equations, the automobiles per household by income bracket equation. Unfortunately, this equation is the cornerstone of the stock-adjustment process. The major findings concerning equation structure are:

- The automobile target stock equation, which drives the model, is incomplete and as a result is thought to be unreliable. The model generates target stock as a function of only income and population, omitting other relevant variables, and limiting the long-run responsiveness of the model to policy variables. The model also ignores all nonhousehold (government, corporate, and institutional) ownership and purchase. Nonhousehold response to policy is likely to differ substantially from household response. Statistical evidence provided by the model does not support the inclusion of the stock adjustment variable in the new-car sales equation, casting serious doubts upon the model's stock adjustment process. The result: the model seems likely to incorrectly predict policy impacts on new-car sales.

- The size composition of new-car sales (market shares) is modeled on the basis of restrictive assumptions that are at best partially correct. In addition, the modeling approach employs a questionable normalization procedure that has anomalous implications. The result: policy impacts on the size composition of new-car sales (hence, ultimately on the composition of the stock of cars in use) are unreliably predicted. Since these predictions are critical in predicting corporate average fuel economy, poor performance here imposes a serious limitation on the model's usefulness.

Forecasting behavior was examined by exercising the Demand Block over the sample period (1963-1973), and the full model over three postsample years (1976-1978). Over the sample period the Demand Block's forecasts had percentage root mean square errors (%RMSE) of 9.14 for new-car sales, 8.89 for scrappage, 3.33 for vehicle miles traveled (VMT), and 6.35 for gasoline consumption. Size-class market shares are least accurately forecast with %RMSEs of 11.03 to 28.89. A naive linear time trend yielded lower mean square errors (MSE) for all forecast variables except small-car market share. A statistical test indicates that a naive time trend outperforms the Faucett model in forecasting VMT, gasoline consumption, and large-car market share. The model's forecasts for the remaining variables are indistinguishable at the 0.05 significance level from those of a time trend.

Over the postsample years, the Faucett model's forecasts of new-car sales and gasoline consumption have lower MSEs than the time trend's forecasts. The model's forecast of VMT has a higher MSE. A statistical test indicates that for these three variables, the postsample forecasting performance of the model and a time trend are indistinguishable at the 0.05 level of significance. However, the real inaccuracy of the sales forecasts generated by the model is suppressed by an adjustment factor, which affects nothing else in the model. Without the adjustment factor the time trend's forecast for new-car sales is indicated at the 0.10 significance level to outperform the model.

Comparison of sample period and postsample period forecasting performance provides some evidence, though not overwhelming, that a time trend performs less well in the postsample period than in the sample period. The model's performance seems to be generally the same for both periods, except for the gasoline consumption forecast, which has a significantly lower MSE over the postsample period. The reasons for this result indicate that users of the model should be aware of the set of subfleet fuel economies present in the version of the model they are using. Furthermore, they should cautiously use the results of this postsample forecasting experiment as an indication of the model's future year forecasting performance.

Sensitivity analysis of the Demand Block indicates that changes in automobile prices and operating (fuel) costs substantially affect the annual new-car sales forecast in the short run, but have no important effects on sales in the long run (after 9 years). No matter what the policy impacts on price and operating cost are, the model predicts only a temporary impact on annual new-car sales. The effects of changes in prices and costs on the forecasts of other variables generally tend to increase over time, which is reasonable. The responses of size composition of sales forecasts are sometimes implausible, often because of the normalization procedure used to ensure that the market shares sum to one. Some of the impact price elasticities implied by the model have positive signs. These incorrectly signed elasticities are contrary to economic theory, and may be attributed to the model structure.

Sensitivity analysis of the Policy Block reveals that large percentage changes in the policy variables produce relatively smaller changes in automobile price and fuel economy forecasts. Fuel economy is particularly insensitive to gasoline price. A point in the model's favor is that the Policy Block is quite insensitive to its most questionable assumptions, although large changes in the assumed technological costs of fuel economy improvements can substantially alter the price and fuel economy forecasts.

General Conclusion. The Jack Faucett Associates Automobile Sector Forecasting Model is a weak forecasting tool, inadequate and unreliable for analysis of government policy alternatives. If policy analysts use the Faucett model, they should correct the model in the ways suggested by the HSRI staff and explicitly account for the numerous problems noted by the HSRI staff prior to any policy recommendation.

CONTENTS

1.0 INTRODUCTION

This report presents an analysis of the Jack Faucett Associates' (JFA) Automobile Sector Forecasting Model (Jack Faucett Associates 1976a, b, & c; Difiglio and Kulash 1976, 1977), performed between September 1978 and August 1980 by staff of the Highway Safety Research Institute (HSRI) of The University of Michigan. The analysis was sponsored by the Motor Vehicle Manufacturers Association (MVMA) and was part of a larger study entitled "Analytical Study of Mathematical Models of the Motor Vehicle System," which has been underway since early 1977.

1.1 Background

The use of mathematical models to estimate and evaluate the impacts of existing or proposed public policies has become common in recent years. Mathematical models attempt to distill a legion of complex interrelationships into a systematic and explicit reflection of the most significant aspects of reality and to reduce large masses of data to key numbers and statistics. The attraction these models hold for those formulating policies concerning complex social problems is obvious. The last decade has seen the extensive development of mathematical models relating to various aspects of the motor vehicle transportation system. These models are used to study the problems of the national highway system, highway safety, environmental pollution, energy consumption, and related areas.

Increasingly, the federal government has used these models, many of which it has sponsored, as tools in research leading to the formulation of policies, regulations, and legislative decisions related to the motor vehicle industry. Notable examples include the use of models in the 1974 Project Independence Study by the Federal Energy Administration (Jack Faucett Associates and Interagency Task Force on Energy Conservation 1974) and by the 1976 Federal Task Force on Motor Vehicle Goals Beyond 1980 (U.S.

Department of Transportation 1976).

The Department of Energy, Energy Information Administration has extensively used these models in annual reports to Congress (U.S. Department of Energy 1978a, 1978b, 1979a, and 1979b). Other federal agencies using motor vehicle transportation models include the National Highway Traffic Safety Administration, Office of Intermodal Transportation, Transportation Systems Center, Federal Railway Administration, Senate Finance Committee, International Trade Commission, Environmental Protection Agency, Department of the Treasury, Council of Economic Advisors, and the Office of Technology Assessment (Saalberg, Richardson, and Joscelyn 1979). The applications generally involve the estimation of the impact of a policy or economic/technological scenario on future automobile demand, vehicle miles of travel, fuel consumption and fuel economies.

Recognition of the increasing role of models in federal efforts to solve critical economic, resource, and social problems led the Highway Safety Research Institute in early 1976 to initiate a preliminary inquiry into the use of models in policy formulation related to the motor vehicle transportation system. ("Policy" includes rules, regulations, legislation, and executive directives.) Within the time frame of that study, approximately thirty models were identified that deal with vehicle production and resource accounting, vehicle miles of travel, automobile sales and pricing, vehicle fleet attributes, and energy factors. It was evident at the end of the preliminary study that the universe of relevant models was large and growing larger. Furthermore, it was concluded that while evaluation of such models is desirable, any in-depth analysis would require computer implementation and exercise of models to assess their capabilities and limitations.

On the basis of the preliminary study, the MVMA agreed to sponsor an effort to expand the inventory of relevant models and to begin detailed analysis and evaluation of selected models. Summaries of some 142 models and 116 abstracts of associated literature have been reported by Richardson, Segel, Barnett, and Joscelyn (1979) and by Richardson, Segel, and Joscelyn (1980). Models selected for analysis were thought to be particularly important to policy formulation processes at the federal level, based on information obtained in the inventory effort. This phase of the "Analytical Study of Mathematical Models of the Motor Vehicle System" began in early 1977.

The study has four broad objectives: (1) to identify and analyze mathematical models relating to the motor vehicle transportation system, (2) to provide the capability to exercise selected models on a computer, (3) to exercise models under alternative assumptions about future conditions, and (4) to develop an understanding of the contexts in which models are used in the policy decision-making process.

Two models were identified as being widely used or whose use may have made significant contributions to policy analysis on the national level. Studies have been completed on the analysis and applications of the Wharton Econometric Forecasting Associates' Automobile Demand Model (Golomb et al. 1979; Saalberg, Richardson, and Joscelyn 1979). The second model chosen for study was the Faucett Automobile Sector Forecasting Model.

This report presents an analysis of the Faucett model's adequacy in meeting the model's stated purpose. This purpose is to forecast the impacts of various federal fuel economy policies on new-car sales, stock of cars in use, vehicle miles of travel, new-car prices, and fuel economies. Readers of this report should be familiar with the Faucett Automobile Sector Forecasting Model. This report will be most useful to those who are familiar with the model.

1.2 Background on the Faucett Automobile Sector Forecasting Model

The econometric equations comprising what is called the Automobile Demand Block of the model were first developed in 1975 by Jack Faucett Associates under the supervision of the Marketing and Mobility Panel of the Interagency Task Force on Motor Vehicle Goals Beyond 1980 (Difiglio and Kulash 1976). The "policy" part of the model, referred to here as the Automobile Industry/Policy Block, was added later under the sponsorship of the Federal Energy Administration (FEA). The model continues to be developed under the sponsorship of the U.S. Department of Energy (DOE).

The model has been used primarily by DOE to forecast the effects of various proposed federal fuel economy policies on gasoline consumption and the behavior of the automobile industry. Model forecasts were used in the 1977 Annual Report to Congress from the U.S. Department of Energy. These forecasts indicated that the automobile manufacturers would not meet the federally mandated fuel economy standards in the 1980s (U.S. Department of Energy 1978b, p. 15; Kelderman 1978), a conclusion that was later revised. The model has also been used by the National Highway Traffic Safety Administration to predict the effects of safety regulations, by the Office of Intermodal Transportation of the U.S. Department of Transportation (Saalberg, Richardson, and Joscelyn 1979, p. 18, p. 21), in DOE's 1978 annual report to Congress (U.S. Department of Energy 1979a,b) and in the 1979 final report of the National Transportation Policy Study Commission (National Transportation Policy Study Commission 1979).

The model's documentation (Difiglio and Kulash 1976, 1977; Jack Faucett Associates 1976a, b, & c; Hittman Associates 1976) describes the original or 1976 version of the model. In August 1977, HSRI acquired a punch card deck containing an updated version of the program. This is the version (referred to as "8/77") that is evaluated in this report. A program listing of the "8/77" revision as received by the HSRI staff appears in Appendix G. The basic structures of the two versions of the model, including all of the estimated coefficients, are the same.

The HSRI staff has received three later versions of the model on tape, called DL1, DL2-76, and DL2-77. These versions are almost identical to the earlier ones, as far as structure and coefficients are concerned, but values for some of the exogenous variables are different. Some of the other differences will be pointed out in later sections. In October 1979, Energy and Environmental Analysis, Inc. (1979) published the results of a study that revised the technological cost relations of the Faucett model. It is not known if those substantial revisions will be incorporated into the model. They are not considered in this model assessment.

Because the model was designed to forecast the impact of federal policies on the automotive industry, it would be appropriate to consider evaluations of the model by governmental agencies, industry itself, and outside parties. At this time the HSRI staff knows of no other evaluations of the Faucett model by independent or governmental organizations. The Motor Vehicle Manufacturers Association prepared two general reports concerning the Federal Task Force on Motor Vehicle Goals Beyond 1980, of which a version of the Faucett model is a part (Motor Vehicle Manufacturers Association 1975, 1976). Another industry perspective of the basis of the model can be obtained from Dr. Henry Duncombe, Sr., who was chief economist for General Motors at the time (Duncombe 1977). It is beyond the scope of this report to evaluate these evaluations. They are cited here so that a potential user of the model or developers of alternative models can fully evaluate the difficulties involved in this approach to modeling the interaction between public policy and automobile industry action.

1.3 Assessing An Econometric Model: Approach of This Report

The Faucett model is primarily a recursive multiple-equation econometric model but also includes a computational block for testing the effects of federal fuel economy policies on the fuel economy ratings and prices of automobiles. An econometric model is composed of equations that summarize relationships among economic and demographic variables. These equations are statistically estimated from historical data, and are used to forecast the results of changes in the exogenous or input variables of the model.

Two important limitations of econometric forecasting should be recognized. First, the validity of a model as a forecasting tool requires that the historical structural relationships among variables continue to hold at least approximately in the future. This is true of any scientific attempt to explain reality. Second, in order to have any confidence in the model's forecasts, the user must have confidence in the projected future values of the exogenous variables that are input to the model.

Four steps were followed in the analysis of the Faucett model: model structure analysis, algorithm and equation analysis, forecasting behavior analysis, and sensitivity analysis. The method used in this analysis is based, in part, on the work by Dhrymes et al. (1972).

(1) In model structure analysis, the logic and theory of the model were examined. Interrelationships among variables and equations of the model were explored with the aid of flow diagrams.

(2) Algorithm analysis is the detailed study of the logic and assumptions of the sections of the model that simulate the automobile industry's responses to federal fuel economy policies. Equation analysis requires reestimation of the model's key equations. Reestimation served to (a) check the data, the specification of the equation and the estimation technique, (b) check the accuracy of the estimated coefficients as indicated in the original model reports, and (c) provide statistical information about the equations.

(3) The forecasting behavior of the model was studied by comparing the results of the model run over the sample and postsample periods with the actual values of the dependent variables. A test was also made to see if the model tends to accumulate errors. The model's forecasting ability was statistically compared with that of naive time trend models.

(4) In model sensitivity analysis, the dynamic properties of the model were analyzed by examining the response of the model to specified changes in the values of independent variables or model assumptions.

1.4 Organization of this Report

Section 2.0 is a brief overview of the entire model. Section 3.0 discusses the algorithms in the Industry/Policy Block that minimize costs while simulating the effects of specified fuel economy policies. Section 4.0 discusses the econometric equations in the Automobile Demand Block that forecast the size and composition of the stock of automobiles, given the input from the Industry/Policy Block. Section 5.0 discusses the implementation of the model as such and its computer program. Section 6.0 deals with the forecasting behavior of the Demand Block, while Sections 7.0 and 8.0 discuss the sensitivity analysis of the Demand and Policy Blocks, respectively. Section 9.0 summarizes the findings of this analysis and presents its conclusions.

2.0 OVERVIEW OF THE LOGIC AND STRUCTURE OF THE MODEL

2.1 Introduction

The Faucett model is a forecasting model designed to estimate the effects of alternative fuel economy and fuel price policies on gasoline consumption, vehicle miles traveled (VMT), new-car sales and prices, market shares, automobile stock (also called fleet size) by size class and vintage (model year), and fuel economy ratings. By manipulating the parameters and variables that describe policies, alternative policies may be studied to determine which produce the most desirable effects. The model may also be used to simulate the effects of specific legislative proposals.

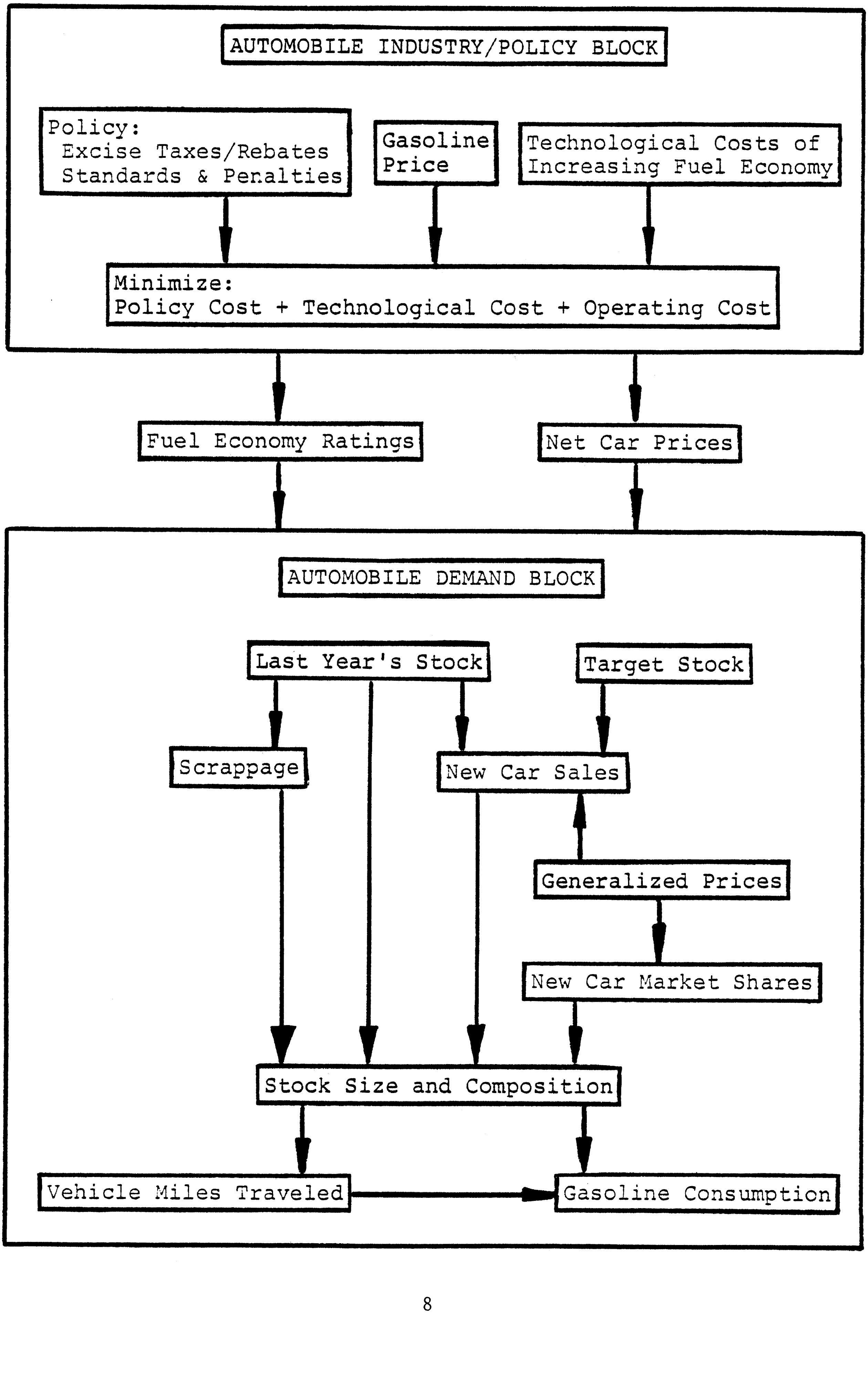
The model is designed for the study of two types of policies. The Standard/Penalty policy option simulates the effects of corporate average fleet fuel economy standards and civil penalty payments like those provided for in Public Law 94-163, the Energy Policy and Conservation Act of 1975 (EPCA). The Excise Tax/Rebate policy option simulates the effects of levying taxes on the purchase of autos with poor fuel economy, and of offering rebate payments for autos with good fuel economy.

The model divides the automobile stock into small, medium, and large size-classes. The choice of policies should, over time, alter the distribution of autos among the classes. Since fuel economy differs among the classes, it follows that total gasoline consumption varies with policy choices.

The model is composed of two major submodels, the Automobile Industry/Policy Block and the Automobile Demand (and Travel) Forecasting Block. The output of the Industry/Policy Block is used as input to the Demand Block. The general structure of the model is illustrated in Figure 2-1.

FIGURE 2-1

GENERAL STRUCTURE OF THE MODEL



2.2 The Automobile Industry/Policy Block

The Industry/Policy Block embodies the supply side of the market. The authors of the Faucett model tacitly assumed that the automobile industry has constant marginal costs. That is, it is as if they assumed a horizontal supply curve for the technological cost and policy cost additions to purchase price. Under this assumption, any change in unit production cost will change the price of an auto by the same amount.

The model user may choose any of five different policy simulation options. The Standard/Penalty or Excise Tax/Rebate options may each be simulated independently, or the two may be simulated together, utilizing the Both option. For the No-policy option the Industry/Policy Block generates fuel economy ratings and prices in the absence of standards or taxes. The Exogenous option allows the user to eliminate the Industry/Policy Block by entering the user's own specification of prices and fuel economy ratings directly to the Demand Block. In addition, policies that raise gasoline prices--for example, gasoline taxes--can be represented by specifying gasoline prices exogenously for all options, including the No-policy option. The model is not designed for use in analyzing policies that restrict or allocate the quantity of gasoline supplied, since the model assumes that the quantity of gasoline supplied is always adequate to meet quantity demanded.

The inputs to the Industry/Policy Block are the policy variables, the technological costs of manufacturing automobiles with different fuel economy ratings, and gasoline prices. Variables used to describe the federal government's fuel economy policies are: the fleet fuel economy standard each automobile manufacturer is required to meet; the penalty levied against the manufacturer per automobile for each unit of miles per gallon (MPG) that manufacturers' corporate average fleet fuel economy (CAFE) falls below the standard; the fuel-economy-dependent excise taxes levied on each auto; and gasoline prices.

The outputs of the Industry/Policy Block are the purchase (retail) prices and fuel economy ratings for each new-car size class. These depend on each other, and are calculated so as to minimize the sum of purchase price and gasoline operating cost of a car. This sum is called the generalized price. Operating cost is a function of fuel economy rating, gasoline price, and miles traveled. Purchase price, also called net price, is the sum of automobile manufacturing cost, technological costs of fuel economy improvements, and taxes or penalties levied because of fuel economy policies.

The Faucett model's attempt to represent the auto industry's reaction to various federal policies is based on the presumption that firms set market prices autonomously. Firms neither take into account the actions or reactions of other firms nor do they adjust their prices in accordance with market conditions. It is assumed that firms minimize generalized price and this assumption is not consistent with conventional economic analysis of industrial organization. Since the assumption is not explained or justified, it is unclear whether a model formulated in this mannner would produce results consistent with a more conventional analysis. In fact, no mention is made of the various competitive forces in the markets for the firms' factors of production or products. All automobile manufacturers, including all the imports, are assumed to have identical production and technological cost functions. Base prices for cars are determined outside the model and within size classes are equal for all manufacturers. Furthermore, the costs of achieving a particular fuel economy for a given car are the same across manufacturers. Also, these regulatory-induced costs are assumed to be totally passed on to the consumer in the current period.

One of the objectives of the Industry/Policy block is to model the firms' reaction to governmental regulation. The reaction is apparently viewed as purely an engineering matter in the sense that only technical calculations need be made. Reaction is not a dynamic process with firms seeking to maximize their profits or market share, or to reach a target rate of return, via alternative strategic courses of action. Because of this, the policymaker cannot simulate policy-relevant impacts of plausible strategic responses by individual firms in the context of the automobile market.

2.3 The Automobile Demand Block

The Automobile Demand Block uses the new-car net prices and fuel economy ratings from the Industry/Policy Block, together with gasoline prices and other economic and demographic variables, to forecast the effects of government policies. The Demand Block tracks the total number of cars in use, and the composition by size class and vintage of this automobile stock, updating these figures each year. National vehicle miles traveled and gasoline consumption are also calculated. The forecast is generated by six econometric equations that estimate scrappage, market shares, household automobile ownership by income bracket, new-car sales, vehicle miles traveled, and annual miles traveled per car by age. Detailed analysis of these equations is presented in Section 4.0. This subsection discusses the interactions of the equations in producing forecasts, and is divided into two parts.

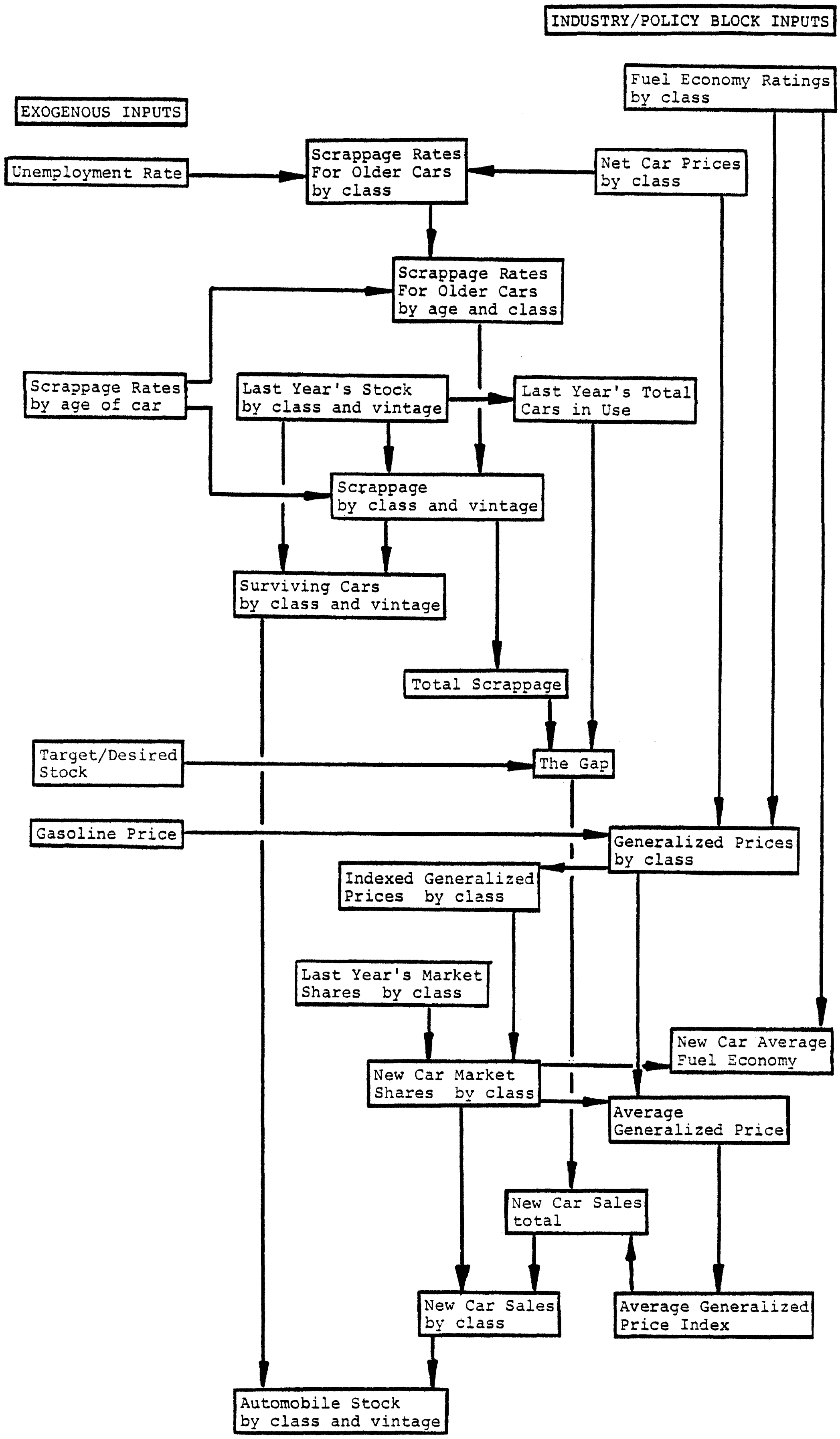
2.3.1 The Demand Block—Part One. Figure 2-2 illustrates the flow of the first half of the Automobile Demand Block, up to the point within the model where the size and composition of the existing automobile fleet are determined.

New-car sales are predicted using a variant of the stock-adjustment process that is commonly used in forecasting automobile demand. The major principle behind this process is that there is a "gap" between the target (or desired) stock and the existing stock of automobiles. The gap is determined by calculating the desired stock of cars, subtracting the existing stock of cars, and adding the number of cars scrapped during the year. In this model the existing stock is that stock of cars on hand as of January 1 of the year. New-car sales represents the current period adjustment towards closing the "gap," and it is a function of both the gap and the price of new cars. The inclusion of the price variable allows the relationship between price and quantity demanded to enter into the model.

The first step in calculating new-car sales is to update the number of cars in existence by subtracting scrappage from the previous year's stock. The model accomplishes this by tracking the number of cars in each of three size-classes for fourteen age groups (that is, forty-two subfleets).

FIGURE 2-2

AUTOMOBILE DEMAND BLOCK - PART ONE



The size of each surviving subfleet equals last year's subfleet, minus the number of cars scrapped. The scrappage rates vary by age. The older a car becomes, the more likely it is to be scrapped. For younger cars (one to eight years old), the model employs rates that are invariant over time. However, scrappage rates for cars nine years and older are made to depend on the unemployment rate and new-car prices. The disaggregated scrappage calculations allow for the derivation of current subfleet sizes. As subfleets differ in fuel economy ratings, gasoline consumption is determined on a disaggregate basis by using the subfleet sizes and fuel economy ratings.

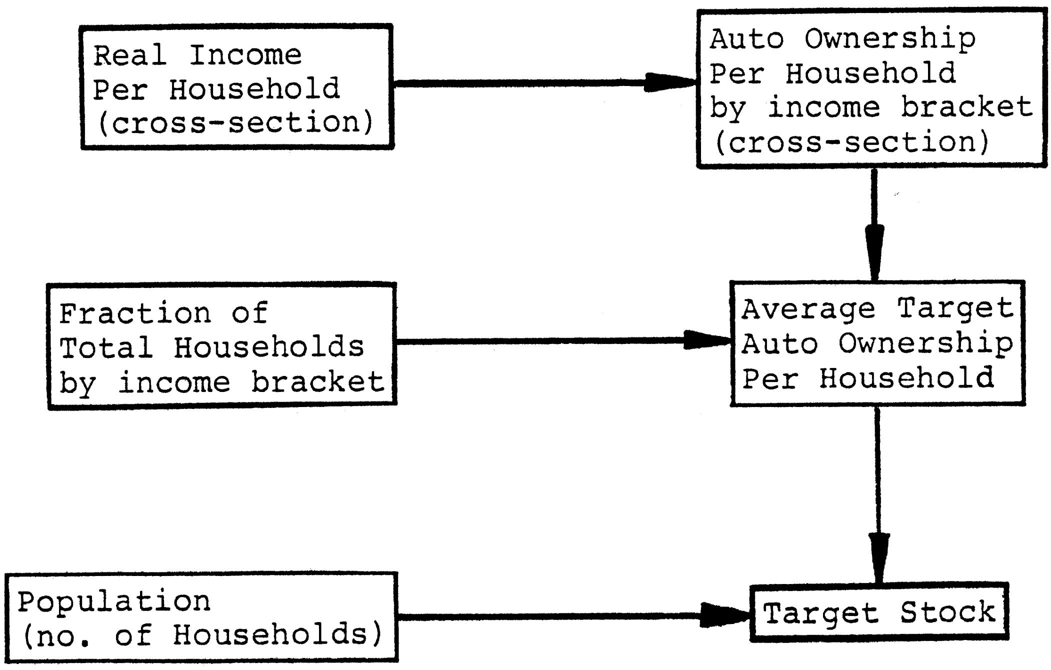
The second step in calculating new-car sales is to forecast the level of the target stock of automobiles. Target stock is the number of cars that the national economy desires, based on income and population characteristics. The process used by the model authors to compute target stock is illustrated in Figure 2-3. The relationship between income and automobile ownership is represented by an econometric equation which, when combined with forecasts of real income per household and the fraction of all households in each income bracket, predicts average household target ownership. This average is then combined with population forecasts to predict target automobile stock.

The third step in computing new-car sales is to estimate generalized price, defined as the sum of a new car's purchase price and lifetime operating costs. Generalized price is the appropriate price variable under the assumption that the decision to buy a new-car depends not only on the purchase price but the operating cost of that car. Generalized prices are estimated for each size class. Predictions of market shares for the size classes are then used to compute the average generalized price used to forecast new-car sales.

The new-car market shares forecasts are based on current relative prices among the classes and the prior-year market shares. The purpose of market share forecasts is to permit analysis of consumer reaction to excise taxes and fuel economies that vary with size class. Thus, the model is designed to allow the user to examine consumer decisions to shift purchases among vehicle size-classes in response to government

FIGURE 2-3

CALCULATION OF TARGET STOCK



policy. Market shares predictions also aid in the analysis of policy effects on gasoline consumption and of the automobile manufacturers' responses to the corporate fuel economy standards.

2.3.2 The Automobile Demand Block—Part Two

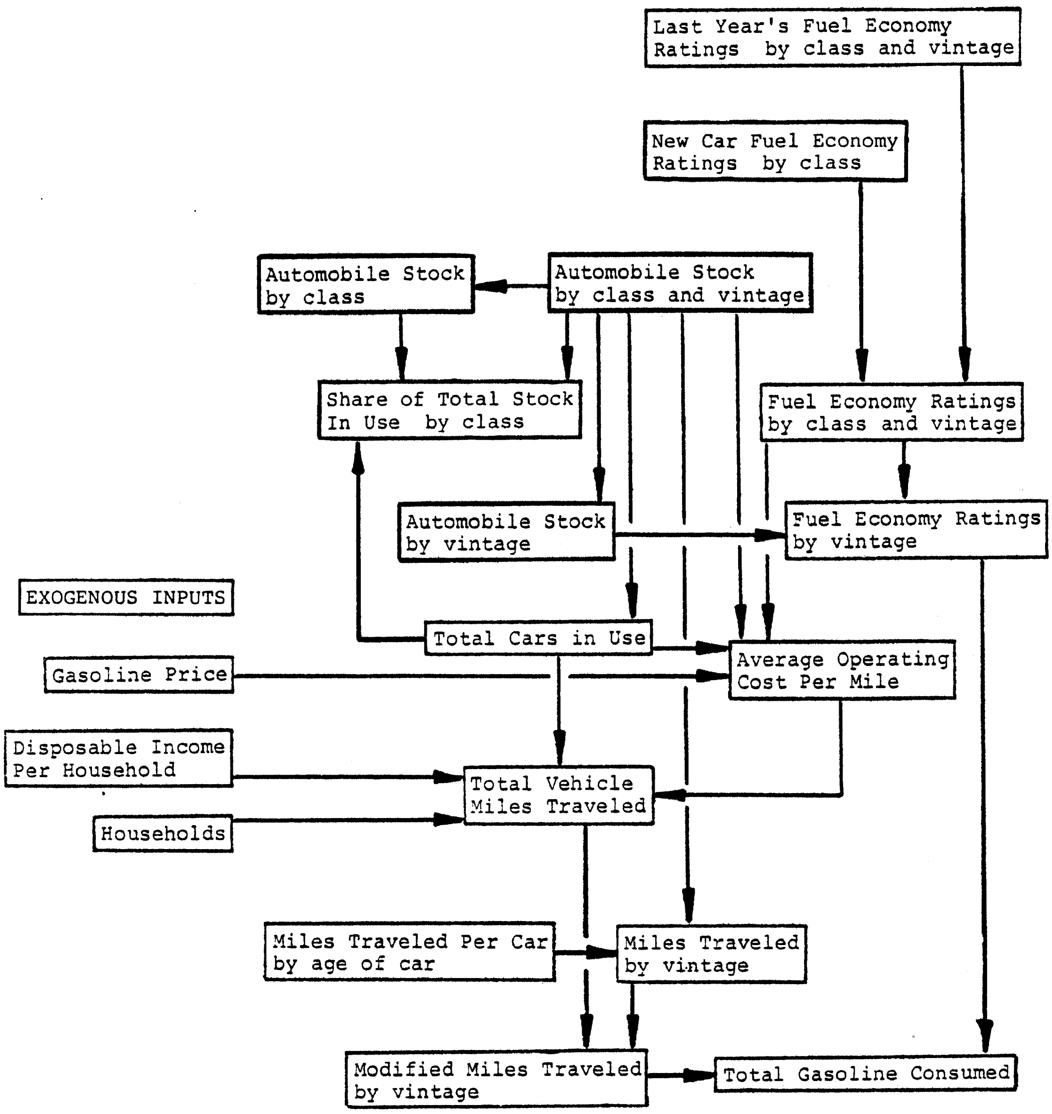
Figure 2-4 illustrates the flow of the model from the point where the size and composition of the fleet are determined. The objective of this part of the model is to forecast vehicle miles traveled and total gasoline consumption.

Aggregate vehicle miles traveled (VMT) is forecast by using an econometric equation that relates VMT to income per household, average operating cost per mile, and total automobile stock per household.

A crude estimate of aggregate gasoline consumption could be derived from the predictions of aggregate vehicle miles traveled and average fuel economy. However, the model provides a better estimate derived from less aggregated data. The model keeps track of the subfleet sizes and the fuel economy ratings for fourteen vintages of cars (this year's new cars, cars one to twelve years old, and cars thirteen years old or older), and calculates the miles traveled by each vintage. These values are obtained by multiplying the size of the subfleet for each vintage by the estimate of the average-miles-traveled-by-age equation. The sum of miles traveled by cars of each vintage will probably not equal the aggregate VMT estimate. The model authors consider the aggregate VMT estimate to be more accurate than the summed VMT by vintage prediction. Therefore, the miles traveled by each vintage are adjusted so that their sum equals the aggregate VMT estimate. Aggregate gasoline consumption is then calculated as the sum across vintages of the product of fuel economy by vintage, in gallons per mile, and the adjusted miles traveled by vintage. The model makes no allowance for fuel economy to decline with vehicle age (1). For instance, a 1977 automobile is assigned the same fuel economy rating in 1985 as in 1978.

FIGURE 2-4

AUTOMOBILE DEMAND AND TRAVEL FORECASTING BLOCK - PART TWO



2.4 The Generalized Price Concept

Generalized prices are used in the model in an attempt to take into account the influence of lifetime operating costs as well as purchase price on the demand for automobiles. A single variable, generalized price, is constructed to overcome the multicollinearity problems caused by the high correlation between vehicle prices and operating cost variables. The model authors simplified the model by assuming that gasoline costs are the only operating costs. However, other important operating costs include maintenance, insurance, parking, and tolls. The Federal Highway Administration (FHWA) has shown that gasoline costs are historically about twenty percent of total operating costs (Cope and Liston 1968; Cope and Gauthier 1970; Liston and Gauthier 1972; Liston and Sherrer 1974; and Liston and Aiken 1976). A more accurate estimate of operating costs requires the inclusion of other important costs. However, this inaccuracy does not imply that variations in gasoline costs are not indicative of variations in total operating costs. Gasoline costs and the sum of all operating costs other than gasoline are highly correlated (2). Thus, gasoline costs may be thought of as a proxy for total operating costs in the model. The use of gasoline cost as the only operating cost in the generalized price variable by Faucett, therefore, agrees with the FHWA data through 1975.

As the model stands, operating costs by size class are a function of the fuel economy rating of the class, the price of gasoline in constant dollars, and a scalar (52,853) representing the discounted, perceived lifetime mileage of new cars.

The fuel economy ratings used in the calculation of operating cost (a part of the generalized price) during estimation of the new-car sales, market share, and VMT equations, are based on U.S. Environmental Protection Agency (EPA) estimates. The fuel economy ratings produced by the Automobile Industry/Policy Block are also based on EPA estimates.

The miles per year of automobile life implicit in the 52,853 figure were drawn from a Nationwide Personal Transportation Study (U.S. Department of Transportation 1972), based on 100,000 miles distributed over a car's lifespan, discounted at an annual rate of ten percent. (Note that it is actually the cost of driving these miles that is discounted, not the miles traveled.) It is then multiplied by a perception factor of 0.8, which in effect reduces the importance of operating costs. The perception factor of 0.8 is said to be used to reflect incomplete consumer awareness of lifetime mileage costs. The rationale for this eighty percent perception factor has not been explained by the model authors, and is not evaluated in this report.

Estimated lifetime gasoline operating costs are sensitive to the discount rate, as would be expected for a decision that has a horizon of this magnitude. Since this factor is so important, more discussion by the model authors about the value selected for the discount rate would have been appropriate. If, for example, real realized (ex post) rates of return had been used, a much lower rate, and thus higher discounted operational cost, would have resulted. If expected or ex ante rates were used, lower cost factors would have resulted. Since these issues are currently under professional debate and are central to the structure of the model, the choice of any particular discount rate needs justification if it is to be accepted in the context of the model.

Another important consideration is that many new-car buyers do not intend to drive their cars until they are scrapped, but sell them after a few years. These buyers may only consider the direct operating costs for those years that they own their cars. If a substantial number of consumers behave in this way, an important part of the model is based on an incorrect assumption. However, if the operating costs of used cars are reflected in used-car prices, then new-car buyers planning to resell will indirectly take into account lifetime operating costs when they consider resale price. These used car resale prices are not included in the model.

A final concern with generalized price is that it is calculated based on a fixed lifetime mileage. One problem is that lifetime mileage is not necessarily fixed. For instance, the durability of automobiles may change. However, simply changing the fixed mileage number will not adequately incorporate durability changes into the model, for two reasons. First, the new-car sales and other equations do not account for durability changes.

Second, in the Faucett model, lifetime operating costs would increase because of increased lifetime fuel consumption if more durable (higher lifetime mileage) cars were built. The model accounts for the costs but not the benefits of changes in durability. Another difficulty with the fixed lifetime mileage is that it assumes that the distribution of mileage over time is constant. If factors influencing VMT change, then even if total lifetime mileage remains unchanged, the distribution of mileage over time would change. This, in turn, means that discounted lifetime operating costs should change.

2.5 Time Coordination of Data: Model Years and Calendar Years

A fundamental conceptual problem with the model structure is its handling of model year and calendar year variables. In the demand block of the Faucett model, the size and composition of the subfleets change in each year of a simulation because of scrappage and new-car sales. The scrappage and new-car sales forecasts are derived on the basis of data describing all of the cars that are scrapped or sold within a one-year period, January 1 to December 31. The Automobile Industry block of the model, however, produces fuel economy ratings and prices for particular model years of cars. Model years are not calendar years: 1977 model-year cars are first sold in the fall of 1976, they are sold throughout 1977, and some are sold in 1978. Mixing fuel economy ratings based on model years with subfleet sizes based on calendar years is inconsistent. The resulting forecast of gasoline consumption is an inherently erroneous blend of model-year and calendar-year forecasts.

This is a common problem in building automobile sector models, since industry data are reported for different periods for different purposes. For instance, corporate average fuel economy ratings, as required by law, are based on model years. New-car registrations, on the other hand, are reported on a calendar year basis. To further complicate matters, model year definitions vary over time. This is exemplified by the introduction of General Motors 1980 X-cars in the spring of 1979 rather than at the traditional fall time. The Faucett model deals with this basic problem by assuming that model years and calendar years are equivalent, and that any resulting errors are minor.

The HSRI staff performed several experiments designed to provide a very rough estimate of the size of the error that results when it is assumed that model years are equivalent to calendar years. Using values for fuel economies, vehicle miles traveled by age of vehicle, and new-car sales, the HSRI staff estimated the error of the prediction of aggregate fuel consumption to be less than two percent. The level of the error in a particular experiment depended on the assumed fluctuations in new-car sales and average new-car fuel economy. The problems associated with the use of model year and calendar year data remain a topic of future research.

2.6 Summary and General Conclusions About the Model Structure

The Faucett model was the first attempt to model the behavior of the automobile sector relating to fuel economy by simulating the changing size and composition of the U.S. automobile stock.

Among the strengths of the model structure:

- Five alternative policy options may be simulated.
- The model disaggregates the total stock of automobiles into forty-two subfleets (three size classes times fourteen vintages).
- Industry response to fuel economy policy alternatives is modeled and allows trade-offs among production costs, fuel economy (operating cost), and policy costs.

Among the weaknesses of the model structure are:

- The representation of the auto industry's behavioral characteristics is oversimplified, omitting some details of interest to policy analysts. In addition, the generalized price-minimizing algorithm may yield different "optimal" prices and fuel economies than would a profit-maximizing model using conventional economic analysis.
- Estimated lifetime operating costs are sensitive to the discount factor. The rate was set at ten percent without explanation and without the capability to simulate alternatives.

- Some parts of the model depend on calendar-year data, while other parts depend on model-year data.

3.0 DETAILED ANALYSIS OF THE INDUSTRY/POLICY BLOCK

3.1 Introduction

The objective of the Industry/Policy block is to simulate the automobile industry's response to various federal policies. Fundamental to the structure of the Block are several assumptions. It is assumed that governmental policies impact equally upon all automobile manufacturers. In addition, it is assumed that the direct economic costs of these regulations and policies are known and that their impacts influence only the auto prices that are set by the automobile manufacturers. The model assumes that the objective of the auto producers is to minimize auto prices inclusive of costs generated in satisfying the regulations, any penalty costs imposed, plus the gasoline operating costs of the cars. In this context, it is presumed that the industry's behavior is a technical engineering matter. The industry acts as if it has known costs, that it has defined engineering methods to be used to achieve the standards, and that it makes an engineering trade-off of higher product price for lower vehicle operating costs. Further, it is assumed that the industry can pass all of these regulatory costs on to the consumer.

It should be noted that these assumptions are questionable. A user of the model does not know what the model presumes about the industrial organization of the automobile industry. Do firms attempt to maximize expected profits, or achieve a target rate of return, or maximize market share? Or are the firms "satisficers"? The user is not provided with an explanation, justification, or empirical verification of the price minimization hypothesis on which the whole industry simulation is founded. One would assume that prices of input factors, the technical production design and engineering conditions, and market structure would all determine the firm and industry supply responses. Simultaneously, the firm would be concerned with the demand for its product. It is not only the industry's technical ability to produce the machines that is important but also the public's (or industry's perception of the public's) willingness and ability to purchase the auto in the market that is important in modeling the industry response. The user of the Faucett model does not know how firms behave. It is tacitly assumed that regulatory constraints do not influence demand per se. Also it is presupposed that market prices are set by the firms, and are set independently of the market's acceptance of the vehicles. Finally, foreign competition is not specifically mentioned. The foreign sector is modeled as if all imports were produced by a single domestic manufacturer. That is, there is no distinction between foreign and domestically produced autos.

For these reasons one should be cautioned when interpreting results and assessing the validity of the model. It may be possible to generate the proposed industry behavior from principles of optimizing firm behavior, consumer demand, and regulatory restraint. However, no such structural model or explanation was available to the HSRI staff.

Two examples of the caution that needs to be taken when dealing with the model concern a related study of the Energy Policy and Conservation Act of 1975, using the Faucett model (Jack Faucett Associates 1976d). The objective of that report was to identify the future effects on the automobile manufacturing industry, automobile sales, the number of cars in operation, vehicle miles traveled, and petroleum product consumption which were created by the Act signed into law on December 22, 1975 (pp.94-163). The projections were run from 1976 to 2000. This is exactly the kind of application for which the model was developed. Two conclusions are interesting. One concerned the General Motors Corporation, and the other small-car sales. As will be discussed in later sections, the model assumes that each manufacturer's market share within the size classes (small, medium, large) will remain constant. Because of this and other factors the report was somewhat cautious in pointing to the fact that "General Motors was the most active [firm of the Big Four] in the large car market, and some degree of additional penetration into the small car market by General Motors would appear to be likely, but the consequences of such a move on each of the Big Four is impossible to predict with much certainty" (Jack Faucett Associates 1976d, p.36).

This uncertainty about forecasting is reinforced by the major changes that have occurred in the industry since 1976. If the industry can be as dramatically altered in the future as in the past, and these changes cannot be forecasted, it might be advisable to employ a much more restrictive planning/forecasting horizon for the model.

The second example is in the same report's conclusion. Here it is said that "the high price of gasoline assumed under the Act would have an especially detrimental effect on this [small car] segment of the automobile market" (Jack Faucett Associates 1976d, p.34). In Section 6.0 of the HSRI report the forecasting behavior of the model is analyzed in detail; Sections 7.2.7 and 7.2.8 discuss the sensitivity of the Demand Block to changes in gasoline price; and Section 8.2 contains an analysis of the effect of gasoline price increases on new-car prices and fuel economies. However, the experience of the 1980 model year would certainly disabuse anyone from believing that higher gasoline prices stimulate large-car sales and retard small-car sales.

One might consider these issues to be relevant only to the Demand Block. However, there is no reason to assume that the Faucett model structure is correct and that the Industry/Policy Block is independent of market reactions, as is assumed in the Faucett model. A better presumption is that market reaction to regulation, general economic conditions, and fuel economy are at the heart of automobile firm or industry reaction to public policy. For these reasons the fundamental structure and underlying assumptions of the Faucett model deserve criticism. Certainly the use of intervals, ranges, or optimistic vs. pessimistic cost and technology estimates rather than point estimates might have conveyed the tenuous nature of these estimates.

With the foregoing criticisms in mind, the HSRI staff proceeded to analyze the industry policy block. The presumption was that even though the policy block and consequently the model was compromised it would be beneficial to examine the Industry/Policy Block in detail. It was hoped that this approach would help to achieve a better understanding and interpretation of the performance of the model as a whole.

3.1.1 Overview of Policy Block. The Industry/Policy Block is intended to simulate the automobile industry responses to various policy alternatives through the user's choice of variables defining the policy options. The responses are prices set by the firms and the fuel economy engineered for each class of auto. Under the Standard/Penalty option, the user is required to specify a corporate average fleet fuel economy standard that the automobile manufacturers must meet, and a penalty. The penalty is the amount that must be paid by the manufacturer to the federal government, for each mile-per-gallon that the corporate average fleet fuel economy rating (CAFE) falls below the standard. Under the Excise Tax/Rebate option the user must input a table of excise taxes (and rebates if desired) that are to be added to (or subtracted from) the cost of a car to yield its net price. These "gas guzzler" taxes are specified according to fuel economy rating. Both options can be applied simultaneously if desired. The model also has a no-policy option to simulate the absence of both the Standard/Penalty and Excise Tax/Rebate options.

The outputs from the Industry/Policy Block are new-car fuel economy ratings and net prices, one pair for each of the three size classes. These outputs are calculated to minimize generalized price (net price plus gasoline operating cost) for each size class. The assumption is that the auto industry responds to consumers and government policy by trading off higher production costs for higher fuel economy. Assuming that the entire burden of policy-imposed costs can be passed on to the consumer is equivalent to assuming a horizontal supply curve for both individual manufacturers and the industry as a whole. Under the Excise Tax/Rebate option the generalized price including the tax (or rebate) is minimized. Under the Standard/Penalty option, generalized price is minimized subject to the constraint that the CAFEs of each of the five auto makers are increased to the standard or to the maximum attainable under the model's policy cost constraint, whichever is less. In short, the Industry/Policy Block forecasts fuel economy ratings and prices for each class of automobile, based on the estimated costs to manufacturers of increasing fuel economy, buyer perceptions of gasoline costs, and regulatory penalties. Manufacturers are assumed to have identical production and cost conditions and they are assumed to minimize their CAFEs up to the standard.

The algorithms described in this section are not fully documented by the model authors. The basic principles of this block of the model, as presented here, were deduced from a detailed analysis of the computer program.

3.2 Constraints Under Which Prices and Fuel Economies are Determined

This subsection details the process of calculating new-car prices and fuel economies in the Industry/Policy Block. Generalized price is defined and the generalized-price-minimizing algorithm is explained. Then the two major policy options (Standard/Penalty and Excise Tax/Rebate) are detailed and related to the price-minimizing algorithm.

Figures 3-1, 3-2, and 3-3 show diagrams of the processes. In those figures, the rectangular boxes represent values of constants or variables. The names of the values are capitalized; lower-case phrases indicate the units in which the value is measured, such as miles per gallon, or the index by which the values are disaggregated, such as by class. The six-sided boxes indicate decision points where various actions might be taken, depending on the values of certain variables. The solid lines indicate the flow of values between calculations of equations. The broken lines indicate logical flow; that is, if a value meets a criterion, then calculations begin again with the box pointed to.

3.2.1 Minimization of Generalized Price.

The operation of the generalized-price-minimizing algorithm is illustrated in Figure 3-1. Total generalized price may be broken down into five components.

(1) Starting price. This is the 1975 cost of producing a car with the starting fuel economy rating for 1975.

(2) Technological or manufacturing cost. These are the costs of achieving the fuel economy rating that is projected as the base fuel economy for the year (beyond 1975) being simulated. The base fuel economy ratings for a year are a set of minimum ratings for each class

FIGURE 3-1

FUEL ECONOMY/COST - GENERALIZED-PRICE-MINIMIZING ALGORITHM

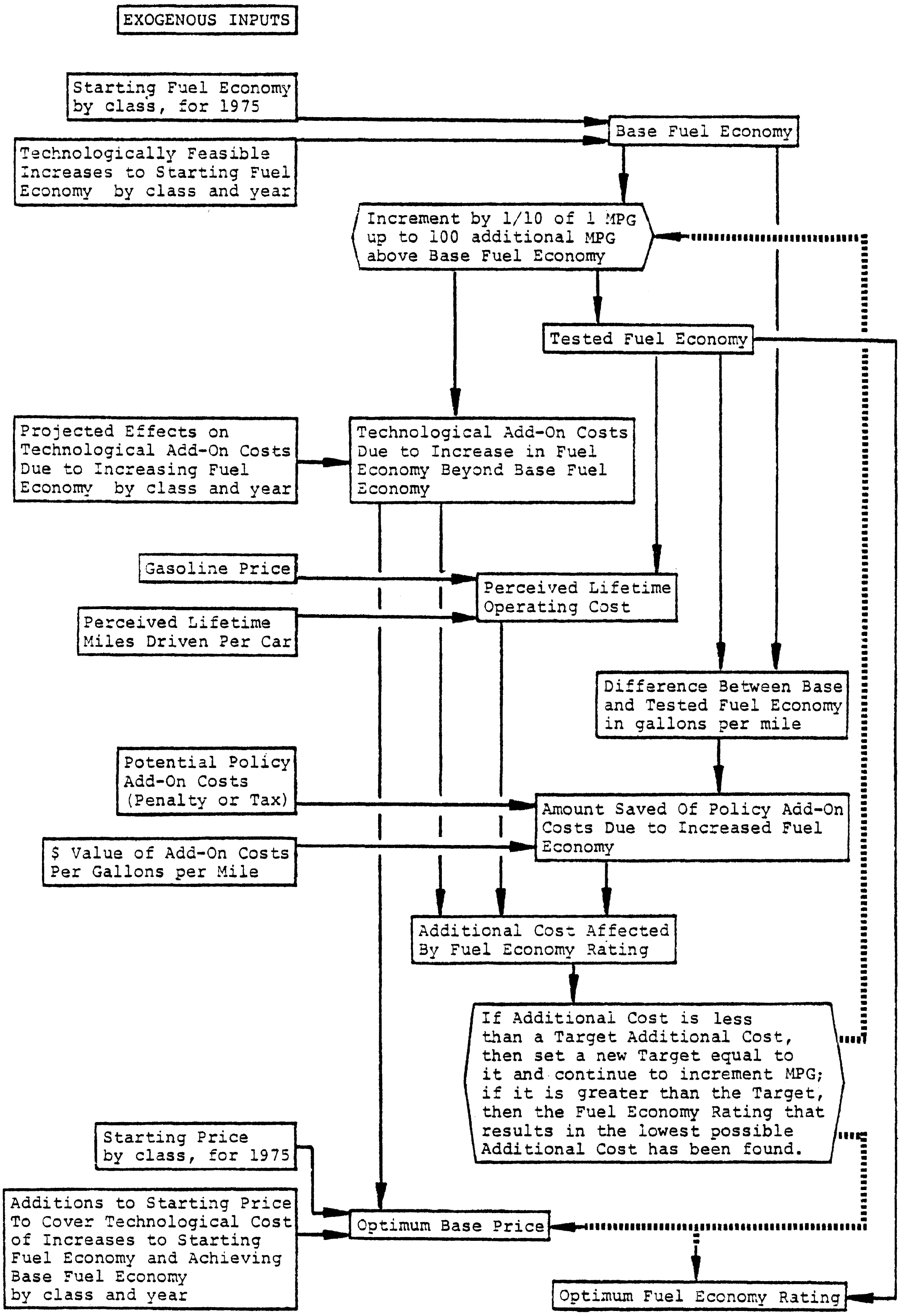
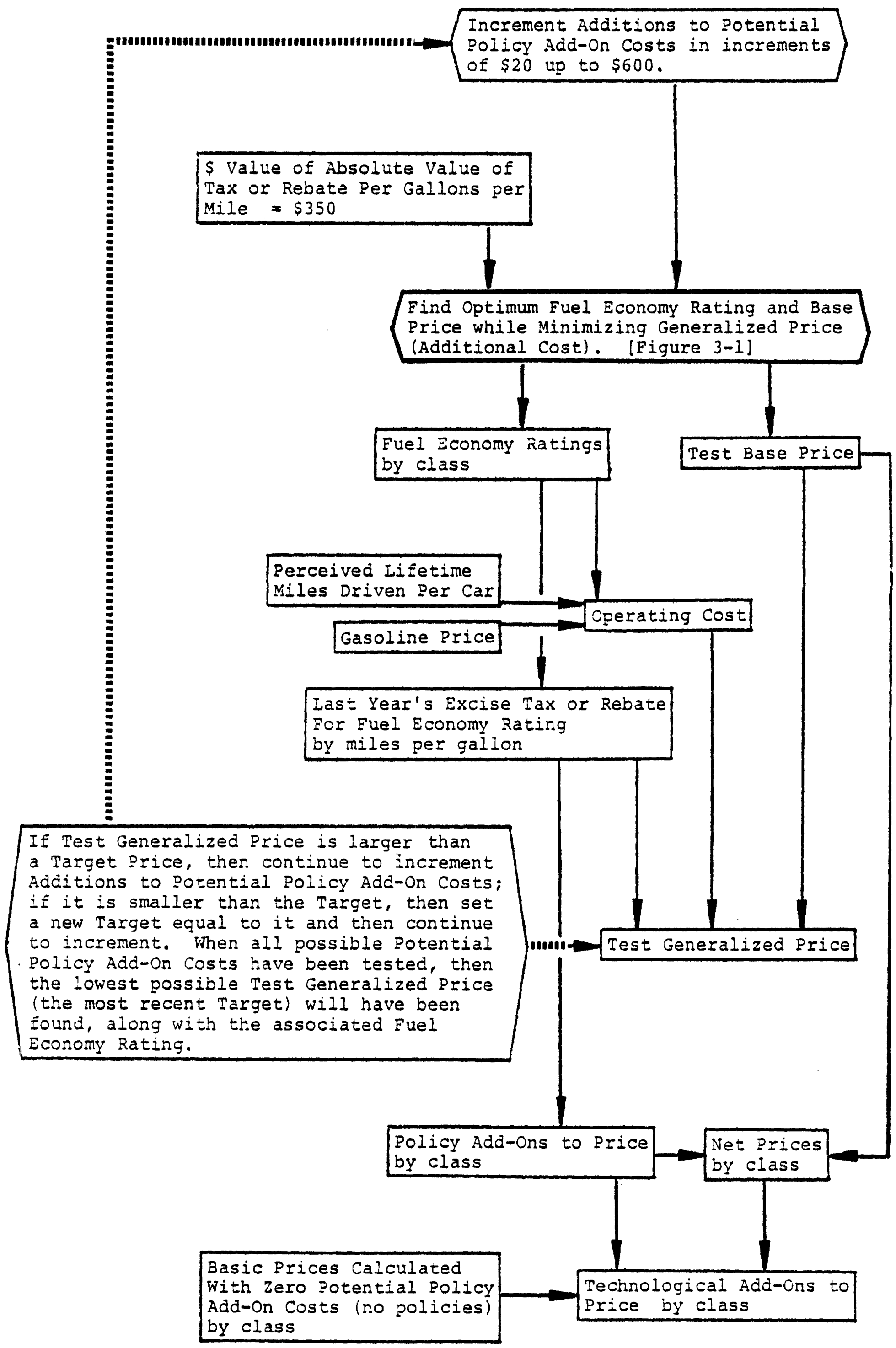


FIGURE 3-2

EXCISE TAX/REBATE POLICY OPTION



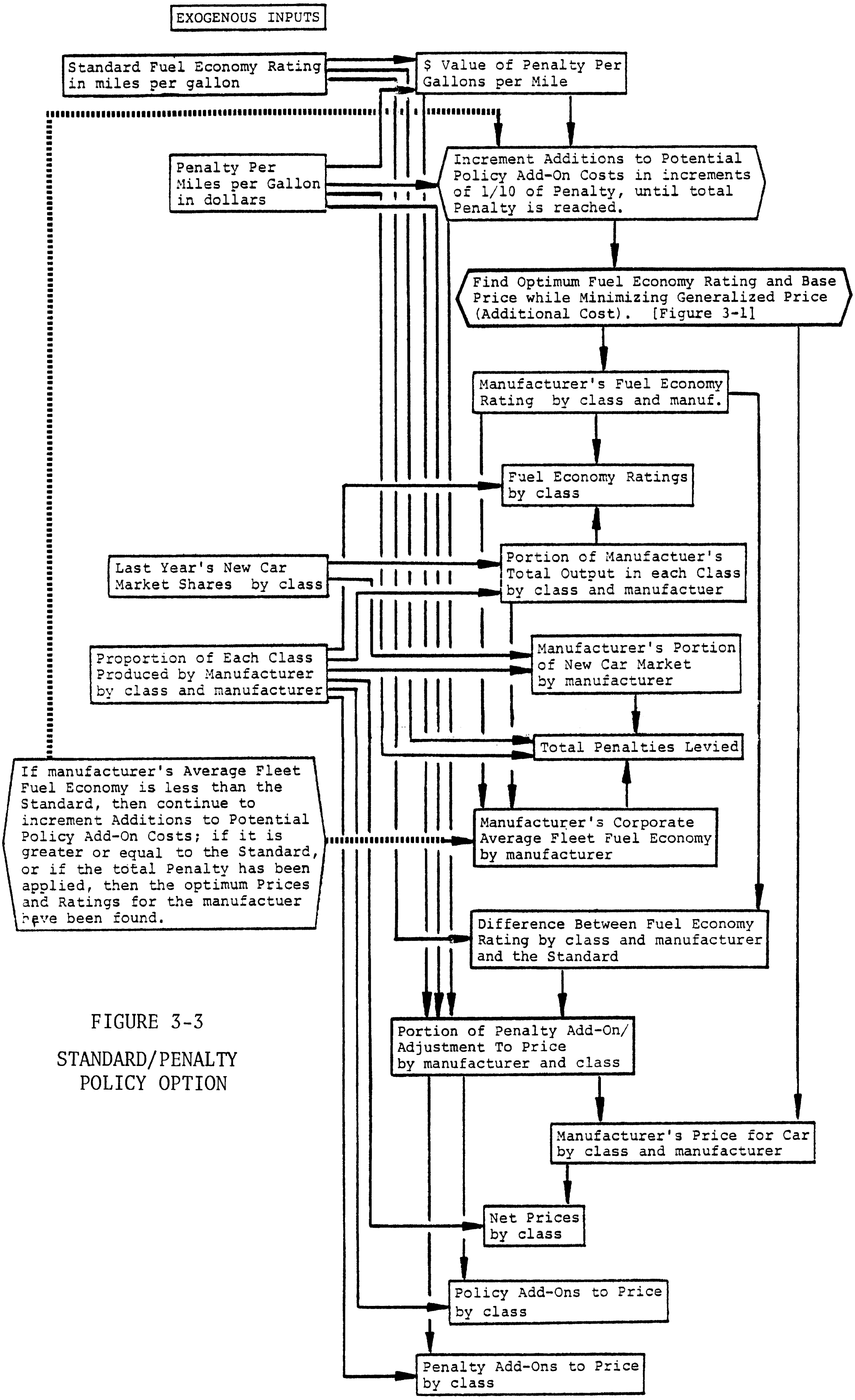


FIGURE 3-3

STANDARD/PENALTY POLICY OPTION

of car that the manufacturers are assumed to achieve. The base ratings, and thus the costs of achieving these ratings, are assumed to increase from year to year.

(3) Technological add-on costs. These are the costs of increasing the fuel economy rating beyond the base ratings. As fuel economy is increased, the technological add-on costs of achieving that rating increase. The generalized-price-minimizing algorithm is iterative; each iteration increases the tested fuel economy rating by another one-tenth of one mile per gallon.

(4) Perceived lifetime operating cost of the car. This is a function of the price of gasoline, the perceived miles that the car will be driven in its lifetime, and the tested fuel economy. As fuel economy rises, gasoline operating cost falls.

(5) Potential policy add-on costs. This represents either a proxy for the excise taxes (rebates) that may potentially be added to (subtracted from) the price in the Excise Tax/Rebate option, or it is some portion of the penalty that may potentially be levied against the manufacturer in the Standard/Penalty option. The policy add-on cost falls as fuel economy rises.

The three components of generalized price affected by the tested fuel economy—technological add-on cost, gasoline operating cost, and policy add-on cost--are summed. The sum is called additional costs because these costs are added to the costs of a car with the base fuel economy rating.

For each year of the simulation, the algorithm determines an optimum price/fuel economy combination. This procedure is based on the assumption that additional costs initially decline as tested fuel economy increases. The rise in technological add-on cost is more than compensated for by the decline in operating cost and policy add-on cost. Eventually, however, increasing tested fuel economy increases technological cost more than it decreases gasoline operating and policy costs. The optimum fuel economy is the tested fuel economy that minimizes additional costs, and has associated with it an optimum base price, which is the sum of the cost of achieving the base fuel economy and the technological add-on cost of surpassing the base fuel economy.

The technological projections are based on estimates of costs of achieving fuel economies, given estimates of technological advances for 1975, 1980, 1985, and 1990. An interpolation procedure is used to determine the technological relationships in the intermediate years for each of the three size classes. Projections beyond 1990 are extrapolations. Thus, the calendar year in a forecast (after 1975) and the size class of a car determine a car's base fuel economy rating and the cost of achieving that rating.

The manufacturing and technological add-on cost projections used in the Faucett model were adapted from a study of projected future relationships between fuel economy and the costs of increasing fuel economy (3). Those engineering design, feasibility, and cost estimates were performed under subcontract to Jack Faucett Associates by Hittman Associates, Inc. (Hittman Associates 1976). In the Hittman report three major policy areas are addressed: environment, safety and damageability, and technological options for fuel economy—with a synthesis of the most probable engine-related technologies to improve fuel economy. The final section was the basis for the Faucett model. Even though the final section may have been the Hittman "best estimate," it was not presented in this way in the Faucett report. In fact, little if any mention of safety issues was made. This is especially interesting in light of the fact that in one of the three possible safety scenarios the Hittman report says ". . . cost increments [due to safety regulation] are significant and in some cases (Scenario III 1985, 1990) dwarf cost increments in corresponding years due to efforts to improve emissions performance or fuel economy" (Hittman Associates 1976, p.61).

That study also states, "it is recommended that . . . this work be viewed more as a tool for subsequent policy/demand analyses than as a definitive prediction of actual fuel economy/cost relationships" (Hittman Associates 1976, p.3). Nevertheless, these fuel economy/cost estimates were used in the Faucett model as if they were definitive for all policy cost estimates. That is, while the Hittman report mentions technological and financial uncertainties, point estimates rather than intervals are used in the Faucett model. More useful information might have been provided if ranges of estimates or confidence intervals were presented instead of the point estimates, which have a semblance of exactness.

Due to resource constraints, the HSRI staff did not analyze the methodology, data, results, or conclusions in the Hittman Associates report. However, since the Hittman study was the empirical basis for the cost estimates used in the Faucett model, a user of the model would be advised to consult that report for details and specifications concerning technological and cost forecasts.

The fuel economy/cost relationships are assumed to be the same for all manufacturers. This assumption ignores the unit cost differences known to exist among auto manufacturers, both within and across domestic and foreign producers. An example of these regulatory cost differences between Chrysler, Ford, and General Motors was recently estimated by Clarkson, Kadlec, and Laffer (1979a). They estimate the fixed unit cost per car to be $345 for General Motors, $340 for Ford, and $550 for Chrysler. The costs were 65% for fuel economy standards, 30% for emissions, and 5% for safety-related regulations. These authors view the costs as a regulatory tax on the firms and this explains the title of their paper "Regulating Chrysler out of Business?", since their burden is roughly 60% greater than that for either Ford or GM. The point here is not about the magnitude of the numbers or the differential effect that regulations may have produced. The point is that issues that are under considerable debate in the literature are not addressed in the Faucett study. For a more detailed explanation of these issues see another study "The impact of Governmental Regulation on competition in the U.S. Automobile Industry" (Clarkson, Kadlec, and Laffer 1979b).

It should be noted that Energy and Environmental Analysis, Inc. (EEA) (1979) has developed new technological cost functions for the Faucett model. Instead of the continuous fuel economy/cost relations estimated by Hittman, the revised model contains discrete segments relating cost and fuel economy improvements. In determining the cost of higher fuel economies, the proposed revisions identify the specific technologies used by each manufacturer for each size-class automobile. Technological market penetrations by manufacturer and size-class are also projected. Thus, the revised relations use an approach that is substantially different from the one used by Hittman Associates. While the EEA report title, Technological/Cost Relations to Update DOE/Faucett model, indicates that the revised fuel economy/cost relations are to update the Faucett model, this would require substantial modifications to the model and its computer program. The revised relations developed by EEA are not considered in this model assessment.

3.2.2 The Excise Tax/Rebate Policy Option. Fuel economy ratings and associated prices are determined under the constraint that the effects of the policy option specified by the model user be applied while minimizing generalized price. In the case of the Excise Tax/Rebate option, taxes (positive or negative) are added to the generalized price. Minimization of this sum determines the market net price and fuel economy combination for a size class. Net price in this case is equal to the optimum base price plus tax, or policy add-on cost.

The taxes that may be specified by the user are for forty fuel economy ratings groups, ranging from one mpg to forty mpg in one-mpg increments, and can be different in each year. Since the user-specified table of taxes is likely to be discontinous, i.e., taxes may rise at uneven rates or in jumps, the model's authors chose to find the cost-minimizing combination of tax payments and fuel economy improvements by testing all possibilities, although a more efficient search algorithm could have been devised. To test all possibilities, the model uses potential policy add-on costs, ranging from $0 to $600 in increments of $20, as a proxy for the user-inputted taxes in the generalized-price-minimizing algorithm described in section 3.2.1 (4). See Figure 3-2.

The use of the potential policy add-on cost as a proxy to determine the impact of user-chosen taxes on generalized prices was designed to serve two purposes. First, the algorithm reduces the computing time necessary to exercise the model under the Excise Tax/Rebate option by computing the effect of taxes over its internally set range rather than over the entire tax table as specified by the model user. Second and more importantly, the proxy is required for simulating the situation that includes both the Excise Tax/Rebate and the Standard/Penalty options. The proxy accounts for the combined impact of both policies.

Figure 3-2 also illustrates how the model computer program isolates the technological add-on cost component of generalized price. It was noted earlier that base price is the sum of the cost of achieving base fuel economy, or the basic price, plus technological add-on cost. The basic price of a car is determined in the absence of policy add-on cost (and therefore technological add-on costs are also zero). Since net price is the sum of base price and policy add-on cost, subtracting the basic price and policy add-on cost from net price yields technological add-on cost.

The problems with the Excise Tax/Rebate option--the use of the proxy for potential policy add-on costs and the limited range and increment of the proxy--are not unacceptable in themselves (5). Together, and in combination with the confusing and undocumented design of the policy option computer code, they comprise an algorithm whose accuracy cannot easily be verified.

3.2.3 The Standard/Penalty Policy Option. Under the Standard/Penalty option, the assumed objective is to minimize the generalized prices of each of the three classes under the condition that each automobile manufacturer is "encouraged" to make its CAFE meet the standard. The standards are established by the EPCA and by the National Highway Traffic Safety Administration (NHTSA), under the authority of EPCA. To encourage manufacturers to meet the standards, a penalty is levied against them if their CAFE does not meet the standard. Currently, this penalty is set by law at five dollars per car produced, for each one tenth of a mile-per-gallon (mpg) that the CAFE is below the standard.

The law also provides for credits that may be earned by manufacturers when their CAFE exceeds the standard. Credits earned in some years may be applied to reducing penalty payments in years when the standard is not met. The Faucett model does not, however, attempt to model this provision. Five manufacturers are modeled, but not identified. Examination of manufacturers' market shares by size-class would lead one to presume they are the Big Four plus a single manufacturer representing all the foreign producers.

The EPCA legislation provides that the CAFE for each manufacturer be calculated each year according to the following formula (U.S. Congress 1975, p.36):

$$CAFE_M = \frac{\sum_C F_M^C}{\sum_C \left(\frac{F_M^C}{FE_M^C}\right)}$$

where

$CAFE_M$ = corporate average fleet fuel economy for manufacturer M

F_M^C = number of automobiles of class C produced by manufacturer M

FE_M^C = fuel economy rating of automobiles of class C produced by manufacturer M

To use this formula in the Faucett model program, it would be necessary to calculate the number of automobiles of each class produced by each manufacturer, F_M^C. This would require modeling the demand for automobiles while differentiating among the five manufacturers. The model authors did not attempt this ambitious project. Instead, a short-cut method was used to produce an estimate of the CAFE. The HSRI staff found it to be unreliable in producing a reasonable estimate. To assign the shares among the five manufacturers, the Faucett model uses predetermined constants specifying the proportion of each class produced by each manufacturer. In other words, to consider a hypothetical example, it is assumed that General Motors will always produce twenty-five percent of the medium-sized cars, Chrysler will produce two percent of the small cars, and so on (see Figure 3-3).

The Faucett model does predict total new-car sales and market shares by size class. These current-period market-shares-by-class predictions could have been used in the Standard/Penalty option part of the model. However, this would require feedback from the Demand Block to the Industry/Policy Block, necessitating the use of a simultaneous equation system. The model authors chose not to use this method, and instead used lagged (last year's) values of the market shares by classes.

It is unrealistic to assume that the proportion of each class produced by each manufacturer is constant, since the relative positions of the manufacturers in the automobile market change over time. The model could have been designed to predict the impact of changes within the automobile industry on sales, shares, and gasoline consumption. The assumption, however, greatly simplifies the model, since it allows the CAFEs to be calculated without requiring any information about the numbers of cars produced. The constant proportion of each class produced by a manufacturer may be combined with the lagged market shares by class (SH_{t-1}), to find the portion of each manufacturer's total output in each class, Q. The CAFE equation can then be simplified as follows:

$$CAFE_M = \frac{\sum_C F_M^C}{\sum_C \left(\frac{F_M^C}{FE_M^C}\right)} \times \frac{\frac{1}{\sum_C F_M^C}}{\frac{1}{\sum_C F_M^C}}$$

$$= \frac{1}{\sum_C \left(\frac{F_M^C}{\sum_C F_M^C} \times \frac{1}{FE_M^C}\right)}$$

$$= \frac{1}{\sum_C \frac{Q_M^C}{FE_M^C}}$$

with $$Q_M^C = \frac{F_M^C}{\sum_C F_M^C}$$

and where

$CAFE_M$ = corporate average fleet fuel economy for manufacturer M

F_M^C = number of automobiles of class C produced by manufacturer M

FE_M^C = fuel economy rating for cars of class C produced by manufacturer M

Q_M^C = portion of total output of manufacturer M in class C

This formula for CAFE is used in the program to find the total penalty to be levied against the manufacturer per car:

$$TPen_M = Pen \times (STD - CAFE_M)$$

where

$TPen_M$ = average penalty to be levied against manufacturer M per car

Pen = penalty amount per unit of mpg

STD = standard fleet fuel economy rating

Penalties, unlike other costs, are not deductible from gross income when taxable income is computed. To be comparable, penalties and costs must be expressed on an after-tax basis. Thus, for firms in the 50% tax bracket, a $50 legislated penalty is the equivalent of $100 in manufacturing costs. The model user is free to choose any tax bracket assumption in specifying the "penalties" to the model's computer program. This allows users to simulate the effects of various marginal tax rates. Unfortunately, the program assumes a 50% bracket when printing the output and divides the "penalties" paid by all manufacturers by two to derive the total penalties actually paid. The user who assumes different tax brackets for manufacturers must correct for this. (The corporate income tax rate was forty-eight percent in 1976 and forty-six percent in 1980.)

For the Standard/Penalty policy option, the penalty amount becomes the potential policy add-on cost input to the generalized-price-minimizing algorithm that generates a fuel economy rating and base price for each class of car for each manufacturer. Since it is possible that the CAFE may meet the standard when less than the full potential penalty cost is tested, an iterative procedure is used that tests successively increasing portions of the full penalty. First, one tenth of the full amount is tested, then two tenths, and so on, until the CAFE meets or exceeds the standard, or the full penalty amount is applied.

The iterative potential-penalty-amount-testing algorithm is repeated for each manufacturer. Then net prices and fuel economy ratings for the size classes are obtained by averaging across manufacturers. These averages are found by using the constant proportions of each class produced by the manufacturers described above. Once again the assumption of constant proportions may not be realistic, but it simplifies the problem of disaggregating by manufacturer and aggregating again for the three classes.

At each level of potential penalty costs, regardless of manufacturer, the generalized-price-minimizing algorithm produces the same fuel economy ratings and base prices for cars in the same class. However, since manufacturers produce different proportions of each class, their CAFEs will be different. Different manufacturers may also meet the standard at different levels of tested potential penalty costs. As a result, fuel economy ratings and prices may differ among manufacturers.

Since the fuel economy ratings differ by class, so do the policy add-on costs that represent the penalty costs the manufacturer attempts to pass on to the consumer via higher prices. The total penalty can be considered to be a lump sum tax. The object of the algorithm is to derive policy add-on costs (in economic terms--internal prices) that will generate the minimum or optimum prices previously discussed. One result of this algorithm is that policy add-ons are negative for relatively fuel-efficient car classes and positive for the relatively fuel-inefficient classes. In effect, these values represent a cross subsidy within the firm. Higher mpg cars subsidize lower mpg cars in terms of meeting the standard, but this is at a cost. The cost differentials are modeled by having reduced (negative) policy add-ons for fuel-efficient and increased (positive) add-ons for fuel-inefficient cars. It is as if it cost more to produce the "gas guzzler" and less to produce the fuel efficient cars. From the producer's point of view, the prices of small cars should be relatively lower in order to sell more, thus making the standard easier to reach. The sum of positive and negative policy add-ons for a manufacturer should equal his total penalty payments. The Faucett model simulates the process by finding the policy add-on costs for each class and manufacturer as a function of the difference between the fuel economy rating for the car and the standard.

The authors of the Faucett model chose to find the policy costs (positive or negative) for each individual class independently of the other two, without knowing in advance the total penalty for the manufacturer or the CAFE. This procedure requires an approximation value, called VALGPM, which may be interpreted as a calibration of the dollar value of the penalty in units of gallons per mile when the fuel economy rating in miles per gallon is close to the standard. In the computer program of the model:

$$\mathrm{Pen}_M^C = \mathrm{Pen} \times \left(\frac{1}{\mathrm{FE}_M^C} - \frac{1}{\mathrm{STD}}\right) \times \mathrm{VALPGM}$$

where

$$\mathrm{VALGPM} = \left(\frac{1}{\frac{1}{\mathrm{STD} - 0.5} - \frac{1}{\mathrm{STD} + 0.5}}\right)$$

Pen_M^C = penalty (positive or negative) applied to cars of class C produced by manufacturer M

FE_M^C = fuel economy rating of cars of class C produced by manufacturer M

Pen = penalty amount per unit of mpg

STD = standard average fleet fuel economy

It is unclear how the expression for VALGPM was derived. The only explanation given in the model documentation (Difiglio and Kulash 1977, p. 94) states: "While [the formula for VALGPM] does not correspond to the EPCA legislation, calculations have shown that within the range of model results provided, very little difference in automobile prices, fuel economies or units produced results." No examples are given to demonstrate this assertion. The validity of the formula as an approximation seems to rest on the assumption that the CAFE is going to be close to the standard.

The HSRI staff has found, however, that it is not necessary to approximate the penalties. Exact penalties can be determined for each class, from the information about the CAFE calculated by the program. The equations which follow show how the exact penalties would be computed. From the equation for average penalties per car:

$$TPen_M = Pen \times (STD - CAFE_M) \times \frac{STD \times CAFE_M}{STD \times CAFE_M}$$

$$= Pen \times \left(\frac{1}{CAFE_M} - \frac{1}{STD}\right) \times (STD \times CAFE_M)$$

$$= Pen \times \left(\frac{1}{\frac{1}{\sum_C \frac{Q_M^C}{FE_M^C}}} - \frac{1}{STD}\right) \times (STD \times CAFE_M)$$

$$= Pen \times \left(\sum_C \left[\frac{Q_M^C}{FE_M^C}\right] - \frac{1}{STD}\right) \times (STD \times CAFE_M)$$

$$TPen_M = \sum_C \left[Q_M^C \times Pen \times \left(\frac{1}{FE_M^C} - \frac{1}{STD}\right)\right] \times (STD \times CAFE_M)$$

Thus

$$Pen_M^C = Pen \times \left(\frac{1}{FE_M^C} - \frac{1}{STD}\right) \times (STD \times CAFE_M)$$

This is the desired equation. This result helps to understand the influence of the Faucett approximation using VALGPM. From the equation used in the computer program for Pen_M^C one derives:

$$STD \times CAFE_M = \frac{1}{\dfrac{1}{STD - 0.5} - \dfrac{1}{STD + 0.5}}$$

$$= STD^2 - 0.25$$

$$CAFE_M = STD - \frac{0.25}{STD}$$

This last equation shows that the approximation assumption constrains the CAFE to be a function of the standard. This, in turn, constrains the range of penalty that may be applied to each class.

When the CAFE is below the standard, the manufacturer will pay a penalty to the government. The policy costs on larger cars will be positive, but generally overestimated because of the approximation method. The policy cost on smaller cars will be negative ("rebates," or reductions in price) and also overestimated generally. In effect, the prices computed by the algorithm are too high for large cars and too low for small cars. The result of this is to alter the size-class market shares. Also, the sum of all of the approximated policy costs are found to be greater than the penalty the manufacturer pays. Because the Industry/Policy Block does not incorporate competitive market reactions, it is not possible to separate the individual effects of incorrect size-class proportions from the incorrect absolute level of policy add-on costs.

The lack of equality between the sum of the penalties on the three individual classes and the total penalty amount calculated by the program using the exact formulation is obscured by the program. It reports penalties by class in 1967 dollars, while the total penalty is reported in 1976 dollars and is divided by two to correct for the previously mentioned tax effect.

To conclude, even accepting the model's simplifying assumption about the constant manufacturer's shares of size-classes, and the use of lagged instead of current year market shares by class, the Faucett model program still incorrectly finds the policy add-on costs to be applied to each class for the Standard/Penalty policy option. An exact formulation would have been possible by judicious use of the program code.

3.3 Summary and Conclusions

The fundamental basis of the Industry/Policy Block is the assumption that individual firms will minimize the combined base price, technological costs of meeting government regulation, and estimated gasoline operating costs. No economic justification for this behavioral objective was presented. All firms were assumed to have identical engineering costs and thus the impacts of government regulation would be equal for all manufacturers. This proposition is at variance with available evidence. It was assumed that the firms' responses to regulation were essentially engineering responses and would be done independently of the economic market for automobiles. Again, no justification for this approach could be found and it is inconsistent with economic theory and statements by industry experts. For these reasons the entire Policy section of the model is suspect. The following points are made in the interest of understanding the Faucett model in its entirety.

The Industry/Policy Block estimates fuel economy ratings and automobile prices for each size class, based on the costs to manufacturers of improving fuel economy, consumer perceptions of lifetime operating costs, and policy-imposed costs. The block is capable of simulating two major policies. Under the Excise Tax/Rebate policy option, new automobiles are assessed taxes or subsidies based on fuel economies. Under the Standard/Penalty policy option, each automaker's corporate average fuel economy (CAFE) is compared to a government determined standard and failure to attain the standard results in the assessment of a penalty. Concurrent use of the two policies as well as the occurrence of neither policy can also be simulated. For the Standard/Penalty policy option, the actions of the five automobile manufacturers are modeled. The manufacturers have an incentive to reach the CAFE standard but not to exceed it.

It may be argued that for some policy analyses, accurate estimation of the levels of predicted variables is not as important as the accurate estimation of relative changes in values caused by different policy variable assumptions. Unfortunately, the primary policy that the model was designed to simulate involves determining whether or not a manufacturer's CAFE will equal or surpass a specific level. The Faucett model has been used to address this very question in a report to Congress (U.S. Department of Energy 1978b, p.15).

Several shortcomings of the Industry/Policy Block have been identified. The model assumes that the entire incidence of the burden of policy-imposed costs is on auto purchasers. This assumption follows from the simplifying assumptions about industry structure. The projected costs to manufacturers of improving fuel economy are not definitive in the Hittman report (on which the model is partially based), yet they are used in the model as if they were definitive. Constants specifying the proportion of each size-class produced by each manufacturer, together with lagged market shares, are assumed to be adequate for determining the relative outputs of the manufacturers. An approximation is used to determine the penalty costs each manufacturer adds to the price of each size class when an exact method is available.

In conclusion, the model is not precise enough to accurately predict the levels of corporate average fuel economy, and should not be considered an adequate tool for an analysis of the impacts of the Standard/Penalty policy.

4.0 ANALYSIS OF THE AUTOMOBILE DEMAND BLOCK

4.1 Introduction

This section presents an analysis of the demand side of the Faucett model. Central to the analysis is the attempt by the HSRI staff to reestimate and verify the econometric equations of the model. The equations discussed in this section are those presented in several reports dealing with the Faucett Automobile Sector Forecasting Model (Jack Faucett Associates 1976a, b, & c; Difiglio and Kulash 1976, 1977). The equations were reestimated using an ordinary least squares technique (as did JFA) available on the The University of Michigan computer system.

Equation reestimation serves three basic purposes:

- To check the specifications, data, and estimation techniques.
- To check the accuracy of the estimated coefficients reported by the model authors.
- To determine the validity of the equations by evaluating statistical information generated in the course of reestimation.

After an equation is reestimated the specification of the equation is analyzed. This analysis involves examining the justification for the inclusion in the equation of each of the independent variables, the omission of possibly important independent variables, and the mathematical form of the equation. The values of the coefficients as estimated by JFA and by the HSRI staff are compared to determine if the size and sign of the estimates are correctly reported and consistent with economic theory. If reestimation fails to duplicate the JFA reported results, the data used to estimate the equation, the sample period of the equation, and the estimation technique are examined to determine possible causes of the discrepancies. However, it is not always possible to completely account for these discrepancies. Finally, the statistics generated in the course of estimating the equations are examined to test the statistical significance of the coefficient estimates and to measure the overall goodness of fit of each equation.

Each subsection of this section deals with one of the major equations and discusses the specification of the equation, the data used in the regression, and the meaning of the statistics generated in reestimating the equation. The estimated coefficients and summary statistics derived by the HSRI staff are presented and compared with the JFA estimates in tabular form. The statistics presented are: the adjusted R-squared ($\bar{R}^2$), the standard error of regression (SER), the Durbin-Watson statistic (DW), the degrees of freedom (DF) and the F-statistic (F). These statistics are briefly described in Appendix A.

4.2 The Scrappage Equation

Historically, the rate at which vehicles are scrapped increases with the age of the vehicle up to eleven years, when the rate seems to level off at roughly thirty percent of the remaining fleet per year. Table 4-1 shows the historic scrappage rates of the automobile fleet by age of vehicle for the model years 1957 to 1973. The rates are based on data in Table 4-2, which shows the auto stock of each year, 1959-1974, by vintage.

In the Faucett model, scrappage rates are determined by one of two methods, depending upon the vintage of the automobile. JFA split the age groups into two categories, depending on whether the scrappage rate was greater or less than twenty percent. The resulting vintage distinctions are less than nine years old and those nine years and older. For cars less than nine years old, the scrappage rates used are those from Table 4-1 and are assumed to remain constant over the forecasting period. For cars nine years or older, a scrappage rate equation is used to modify the rates in Table 4-1. This equation is intended to produce scrappage rates based on economic conditions and replacement costs during the current year. This information implies that the scrappage rates of older cars are significantly affected by the economic environment, but the rates of newer cars are not.

TABLE 4-1

HISTORIC SCRAPPAGE OF THE AUTOMOBILE FLEET, BY AGE OF VEHICLE

MODEL YEAR M	PERCENT OF CARS SCRAPPED DURING YEAR	PERCENT OF VEHICLES IN USE AT END OF YEAR
M		100.00
M + 1	0.2	99.80
M + 2	0.55	99.25
M + 3	1.05	98.21
M + 4	2.01	96.23
M + 5	3.47	92.90
M + 6	6.02	87.03
M + 7	10.16	78.43
M + 8	15.70	66.12
M + 9	21.46	51.93
M + 10	26.00	38.43
M + 11	28.89	27.33
M + 12	30.15	19.09
M + 13	30.00	13.36
M + 14	29.17	9.46
M + 15	29.29	6.69
M + 16 and older	29.70	

Source: Difiglio and Kulash 1976, pp. 2-169

4.2.1 Specification of the Equation. The scrappage rate equation developed by JFA estimates a single average scrappage rate for all older cars. This scrappage rate is specified as a function of new-car prices (measure of replacement costs), and the unemployment rate, which the model authors use to measure temporary fluctuations in general economic conditions (Difiglio and Kulash 1976, p. 2-171). The model authors expect higher prices for new cars and higher unemployment rates to cause people to hold on to their old cars longer, resulting in lower scrappage rates.

JFA assumed a linear function for the equation and estimated the relationship to be:

$$SPG_t = 0.40675 - 0.078433\ (NP_t^*) - 0.015519\ (U_t) \qquad (4.1)$$

where

SPG_t	=	the rate of scrappage in year t of vehicles nine years old and older
NP_t^*	=	an index of the average net price of cars in year t, 1967 = 1.00
U_t	=	the unemployment rate in year t

4.2.2 Data Used in the Regression. Table 4-3 contains data used for the regression and was supplied to the HSRI staff by JFA. The SPG_t data points can be calculated from the data in Table 4-2. The SPG_t for year t is equal to the sum of registrations of cars nine years and older in year t minus the sum of registrations of cars ten years and older in year t+1, divided by the first sum. For example, using 1960 and 1961 data from Table 4-2, the 1960 scrappage rate (for cars 9 years and older) is determined as follows: $[(3598 + 3559 + \ldots + 804) - (2884 + 2790 + \ldots + 690)] \div (3598 + 3559 + \ldots + 804) \approx .224$, which equals SPG_{1960} in Table 4-3. Thus, the 1960 scrappage rate is for the period July 1, 1960 to June 30, 1961.

Since the exact method of calculation of the average net price data, NP_t, used by JFA is unknown, the net prices were not verified by the HSRI staff. However, the HSRI staff attempted to derive the net prices

TABLE 4-2

PASSENGER CAR REGISTRATIONS - CARS STILL IN USE BY MODEL YEAR ON JULY 1 OF EACH YEAR IN THOUSANDS OF UNITS*

Model Year of Car's Origin — Time in Calendar Year

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1973	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7,988	6,433
1972	....	....	....	....	....	....	....	....	....	....	....	....	....	7,169	10,158	11,269
1971	....	....	....	....	....	....	....	....	....	....	....	....	5,927	8,915	8,715	10,147
1970	....	....	....	....	....	....	....	....	....	....	....	6,288	8,888	8,851	8,612	8,622
1969	....	....	....	....	....	....	....	....	....	....	6,465	9,299	9,280	9,122	8,881	8,493
1968	....	....	....	....	....	....	....	....	....	6,182	8,927	8,816	8,802	8,596	8,291	8,615
1967	....	....	....	....	....	....	....	....	5,822	8,122	8,055	7,878	7,772	7,499	7,120	7,931
1966	....	....	....	....	....	....	....	6,239	8,859	8,836	8,798	8,538	8,313	7,930	7,333	6,624
1965	....	....	....	....	....	....	6,408	9,013	8,948	8,939	8,855	8,506	8,171	7,583	6,715	6,531
1964	....	....	....	....	....	5,847	7,855	7,826	7,738	7,667	7,532	7,116	6,651	5,920	4,963	5,710
1963	....	....	....	....	5,298	7,348	7,315	7,309	7,182	7,058	6,829	6,268	5,624	4,713	3,698	3,976
1962	....	....	....	4,556	6,605	6,629	6,626	6,573	6,401	6,183	5,804	5,058	4,274	3,343	2,470	2,824
1961	....	....	3,809	5,507	5,451	5,455	5,385	5,281	5,026	4,657	4,087	3,267	2,525	1,824	1,268	1,813
1960	....	4,132	6,167	6,195	6,190	6,134	6,002	5,758	5,274	4,615	3,726	2,776	2,034	1,413	967	901
1959	3,806	5,765	5,817	5,781	5,719	5,586	5,405	4,949	4,229	3,347	2,452	1,692	1,183	805	548	682
1958	4,292	4,288	4,313	4,277	4,166	3,972	3,640	3,045	2,359	1,709	1,188	799	563	389	274	391
1957	5,999	5,966	5,932	5,840	5,578	5,124	4,527	3,623	2,739	1,990	1,422	996	730	527	*1,781	*1,621
1956	5,928	5,841	5,766	5,614	5,258	4,683	3,979	3,076	2,255	1,612	1,139	794	580	*1,813	....	....
1955	6,673	6,539	6,368	6,055	5,501	4,715	3,853	2,890	2,089	1,495	1,063	752	*1,804	....	....	....
1954	4,502	4,352	4,110	3,744	3,215	2,634	2,031	1,480	1,049	743	525	*1,583	....	....	....	....
1953	5,444	5,103	4,585	3,936	3,205	2,471	1,823	1,280	889	623	*1,578	....	....	....	....	....
1952	3,282	2,925	2,464	2,005	1,568	1,177	856	593	421	*1,517	....	....	....	....	....	....
1951	4,275	3,598	2,884	2,243	1,716	1,289	932	654	*1,628	....	....	....	....	....	....	....
1950	4,327	3,559	2,790	2,150	1,661	1,251	931	*1,563	....	....	....	....	....	....	....	....
1949	2,627	2,042	1,537	1,149	865	631	*1,368	....	....	....	....	....	....	....	....	....
1948	1,259	959	720	537	415	*1,053	....	....	....	....	....	....	....	....	....	....
1947	900	661	482	351	*867	....	....	....	....	....	....	....	....	....	....	....
1946	452	326	237	*719	....	....	....	....	....	....	....	....	....	....	....	....
1942	97	75	*690	....	....	....	....	....	....	....	....	....	....	....	....	....
1941	333	*804	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1940	*734	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1939	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1938	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1937	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1936	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Not known	155	168	180	201	215	52	4	112	60	63	50	22	16	27	23	25
TOTAL	55,087	57,103	58,854	60,860	63,493	66,051	68,940	71,264	72,968	75,358	78,495	80,448	83,137	86,439	89,805	92,608

* Includes all earlier year models.

SOURCE: R. L. Polk and Company.

Source: Automotive News, Almanac Issue 1975, p. 70

*The placement of the data in the 1974 column is in error. For that year, the model year data should be moved up one year. For example, the number of 1973 model year cars registered on July 1, 1974 should be 11,269 not 6,433. This error did not result in any errors by the model authors, insofar as the HSRI staff has been able to determine.

TABLE 4-3

DATA USED IN SCRAPPAGE RATE EQUATION

Year	SPG_t	NP^*_t	U_t
1960	.224	1.178	5.5
1961	.225	1.166	6.7
1962	.214	1.149	5.5
1963	.223	1.129	5.7
1964	.226	1.111	5.2
1965	.269	1.068	4.5
1966	.270	1.019	3.8
1967	.279	1.000	3.9
1968	.282	.987	3.6
1969	.283	.951	3.5
1970	.256	.925	4.9
1971	.262	.923	5.9
1972	.258	.886	5.6
1973	.236	.835	4.9

Source: Jack Faucett Associates, Inc.

from a table of generalized prices provided by JFA, using the procedure shown in Appendix B. The price index data calculated from the net prices in Appendix B differs from the price index data JFA used in the estimation of the scrappage equation. The source of this discrepancy is not known, but it seems to indicate an inconsistency in the values of net prices used by JFA in different parts of the model. The unemployment data were verified to be those reported by the Bureau of the Census.

4.2.3 Statistics and Interpretation. Table 4-4 contains the results of the HSRI staff and JFA estimates of the regression coefficients. The differences between them are less than one percent. The signs of the price and unemployment coefficients are, as expected, negative.

JFA obtained their estimates of the coefficients by using a sample period of 1960 to 1973 excluding 1968. The HSRI staff estimated the scrappage equation over two alternative sample periods, 1960-1973 and 1960-1972. These coefficients and related statistics are in Table 4-5. The reasons for dropping 1968 from the sample were not obvious to the HSRI staff and not explained by JFA. The appropriate statistical test failed to indicate that 1968 was from a different population than the other observations. JFA's exclusion of 1968 from the sample period does not significantly alter the estimated coefficients. A more important finding is that 1973 is indicated to be from a different population than the 1960-1972 observations. If 1973 is deleted from the sample period, the values of the estimated coefficients are significantly changed (6). This extreme sensitivity of the scrappage equation to a single observation is disturbing, and may suggest that the equation inadequately represents the scrappage process because of omitted variables. Among the potentially important omitted independent variables are employment, income, and measures of activity in the steel scrap market. Employment rose slightly over the 1973-1974 period. The steel scrap market experienced sharply rising prices, but consumption and production fell over the same period. Thus, these two influences do not appear to be responsible for the lower scrappage rate in 1973. A possible cause for it, however, may be found in income, for GNP fell beginning in the second quarter of 1973, through

TABLE 4-4

SCRAPPAGE EQUATION
ESTIMATED COEFFICIENTS AND STATISTICAL RESULTS

(Standard errors in parentheses)

Estimated equation: $SPG_t = a + b_o[NP^*_t] + b_1[U_t]$

Sample Period 1960-1967 1969-1973 1968 dropped	Constant	Coefficient of NP^*_t	Coefficient of U_t	$\bar{R}^2$	SER	DW	DF	F
JFA	0.40675 (0.04127)	-0.078433 (0.04104)	-0.015519 (0.005085)	.5904	0.01544	1.9087	10	9.65
HSRI	0.40730 (0.04162)	-0.07847 (0.04136)	-0.01560 (0.00518)	.5849	0.0155	1.89	10	9.46

TABLE 4-5

SCRAPPAGE EQUATION OVER ALTERNATIVE SAMPLE PERIODS

(Standard errors in parentheses)

Estimated equation: $SPG_t = a + b_o[NP_t{*}] + b_1[U_t]$

	Sample Period	Constant	Coefficient of NP_t^*	Coefficient of U_t	$\bar{R}^2$	SER	DW	DF	F
HSRI	1960-1973	0.41152 (0.03918)	-0.07738 (0.03980)	-0.01656 (0.00459)	.6376	0.0150	1.94	11	12.436
HSRI	1960-1972	0.46257 (0.03217)	-0.13483 (0.03351)	-0.01436 (0.00338)	.8206	0.0108	2.65	10	28.444

1974 and into the first quarter of 1975. In addition to this omitted variable, an event unique to the 1973 data point is the oil embargo of October 1973-March 1974 and the OPEC price increases.

In order to account for fuel consumption by the various subfleets of the automobile stock, the Faucett model tracks the current size of each subfleet. This requires estimates of the number of cars scrapped in each subfleet. For the cars less than nine years old, the scrappage rates are assumed constant across classes and constant over time. Those rates are indicated in Table 4-1. For cars nine years and older, the rates are determined in a two step process. First, for each year in the forecast, the unemployment rate and the three indexes of new-car net price by class are substituted into the scrappage equation to produce scrappage rates for older cars in each class. (Recall that this equation was estimated with average net price indexes, not the individual class-price indexes.) Second, these rates by class are combined with scrappage rates by vintage to develop scrappage rates by class and vintage. For further discussion of the determination of the scrappage rates by class and vintage, see Section 5.4.

JFA used the scrappage equation to produce these subfleet scrappage rates because historical data on the subfleets are unavailable. The substitution of the net price indexes into the scrappage equation in an attempt to estimate unknown scrappage rates for each class is entirely unexplained. There is no apriori reason to believe that the resulting rates will accurately predict subfleet sizes for the purpose of estimating gasoline consumption.

4.2.4 Conclusions. The HSRI staff was able to closely reproduce the JFA estimated scrappage equation. However, the sample period used by JFA excludes the 1968 observation for no apparent reason. More importantly, the estimated coefficients were found to be sensitive to small changes in the data, in particular the 1973 sample point, and the HSRI staff regards the JFA estimated coefficients as unreliable.

The calculation of subfleet scrappage rates by replacing the average net price index in the scrappage equation with the net price index of each class is not justified.

4.3 New-Car Sales Equation

The new-car sales equation involves a stock adjustment process. Such processes are widely used in forecasting automobile demand. In the Faucett model, the forecast of new-car sales is critically based on both the new-car sales equation and forecasts of desired (target) automobile stock.

4.3.1 Computation of Target Automobile Stock. To calculate the target automobile stock, JFA used the following equation:

$$O_t^* = (\sum_I H_I \times P_{It})\ HHLD_t \qquad (4.2)$$

where

O_t^* = target automobile stock in year t

H_I = automobile ownership per household in income bracket I

P_{It} = fraction of total households in income bracket I in year t

$HHLD_t$ = total number of households in year t

Average automobile ownership per household is computed as a weighted average of the estimates of ownership per household estimates by income bracket, with the weights being the fractions of households within income brackets. Target stock is the product of average target automobile ownership per household and the number of households. Before considering the problems with target stock, a short digression is required.

The critical variable in equation 4.2 is H_I, the automobile ownership per household in income bracket I. JFA developed data for this variable with an econometric equation that estimates automobile ownership per household as a log linear function of real income. This functional form reflects the observation that the number of automobiles owned per household increases at a decreasing rate as income rises. Using four different data sources spanning thirteen years, the model authors estimated alternate versions of the equation. Comparison showed that estimated coefficients were relatively stable over 1960-1974 (Difiglio and Kulash 1976). JFA chose to use the following equation estimated from 1970 data:

$$H_I = 0.01786\ (I)^{0.4743} \tag{4.3}$$

where

H_I = automobile ownership per household in income bracket I

I = total real income by bracket

Table 4-6 contains the census data JFA used to calculate the household auto ownership by income data points used to estimate equation 4.3. Since the HSRI staff had only this census data, calculations were required to reconstruct the data points used to estimate equation 4.3. Using 1970 data, the HSRI staff computed the following: for each income bracket, automobiles per household equals one times the percentage of households having one car, plus two times the percentage of households having two cars, plus 3.1 times the percentage of households having three or more cars (3.1 is used since some households in the final category have more than three cars). This computation produces an average number of automobiles per household figure for each income bracket shown in Table 4-7.

To use these data in a regression, an income point for each income bracket had to be selected. The HSRI staff used the midpoints of the income brackets and $22,000 for the highest income bracket. These points are also shown in Table 4-7.

Two final statements about the calculation of the data points need to be made. First, the HSRI staff used the same income midpoints as JFA in estimating the coefficients. Second, the HSRI staff ignored the not-reported income group in its computation of Table 4-7; it is not

TABLE 4-6

PERCENT OF HOUSEHOLDS OWNING ONE, TWO, OR THREE OR MORE CARS BY INCOME BRACKET IN JULY 1970

	ONE CAR	TWO CARS	THREE OR MORE CARS
All Households	50.3	24.6	4.7
Income* Under $3000	38.0	3.8	0.7
3000 to 4,999	55.9	11.8	1.5
5000 to 7,499	64.3	19.5	2.6
7500 to 9,999	56.9	29.9	4.8
10,000 to 14,999	47.5	40.2	8.2
15,000 and over	33.1	50.4	12.7
Not Reported	52.9	22.0	4.8

Source: U.S. Bureau of the Census. 1970. Current Population Reports. Series P-65. Table 1.

* Total money income of primary family in 12 months immediately preceding interview.

TABLE 4-7

AUTOMOBILE OWNERSHIP PER HOUSEHOLD BY INCOME BRACKET

Total Income in 1970 Dollars	Cars Owned Per Household	Income Bracket Midpoints
< 3000	.4777	1500
3000-4999	.8415	4000
5000-7499	1.1136	6250
7500-9999	1.3158	8750
10,000-14,999	1.5332	12500
≥ 15,000	1.7327	22000

Source: Calculated from data in Table 4-6.

known how JFA treated that group.

Table 4-8 presents the JFA and HSRI estimates of the auto ownership equation coefficients. A comparison of the results shows that the differences between the estimates are large, almost five percent for the exponential coefficient. Discussion with the model authors did not resolve these differences. The effect of these differences on target stock is at least five percent, which is large in absolute terms since the fleetsize is roughly 100 million.

Keeping in mind the above digression on household ownership, consider again equation 4.2. The cross-section estimation of target stock is seriously flawed. First, the model authors assume that actual stock equaled desired stock in 1970. Had the model authors used a conventional stock adjustment model (Chow 1957; 1960), which they did not, this would have been unnecessary. Insofar as desired stock differed from actual in 1970, estimated target stock for other years will be biased. Second, the model authors assume that the cross-sectional relationship between income and household auto ownership is the same as the time-series relationship, with an adjustment for an income saturation effect (7).

Another fundamental problem with the specification of the target stock in the Faucett model is that fleet sales of automobiles to car rental agencies, government, corporations, and others, are omitted. This omission from target stock further weakens the model's stock-adjustment procedure, especially since fleet sales are a growing proportion of the market. Vehicles in fleets tend to be driven more miles and resold relatively sooner than other new cars; consequently, fleet purchases may not parallel household purchases. Fleet sales generally increased as a percentage of total sales over the last decade, with fleets of ten or more cars accounting for over 13% of sales in 1977 (Shonka 1979). The problem of fleet sales is not peculiar to the Faucett model; no auto demand model that the HSRI staff is aware of deals directly with this issue. Nevertheless, failure to account for fleet ownership is a serious flaw in the specification of the model.

Another problem with the specification of target stock is that it depends only on income and population. Purchase price, operating costs,

TABLE 4-8

AUTOMOBILE OWNERSHIP PER HOUSEHOLD BY INCOME BRACKET EQUATION
ESTIMATED COEFFICIENTS AND STATISTICAL RESULTS

(Standard errors in parentheses)

Estimated equation: $\log(H_I) = a + b\,[\log(I)]$

Cross Sectional Data from 1970	Constant	Multiplicative Coefficient	$\bar{R}^2$	SER	DW	DF	F
JFA	-1.7481	0.4743	.962	--	--	4	46.26
HSRI	-1.80674 (0.15175)	0.49736 (0.04083)	.967	0.0371	1.21	4	148.36

Estimated using 1958 dollars.

and characteristics of the driving population are among the explanatory variables notably absent (although price and operating cost do enter the new-car sales equation directly).

4.3.2 Specification of the New-Car Sales Equation. The first step in predicting new-car sales using the JFA stock adjustment process is to find the "gap" between existing and desired stock. The gap is computed as the difference between the target stock and the beginning-of-year total stock minus the number of vehicles scrapped during the year:

$$O_t = O_t^* - (Autos_t - D_t) \tag{4.4}$$

where

O_t = gap between target and existing stocks

O_t^* = target automobile stock in year t

$Autos_t$ = stock of automobiles on hand at the beginning of year t

D_t = total scrappage of vehicles in year t

JFA estimated the new-car sales equation to be in the following form:

$$\log(N_t) = 5.45746 + 0.21779\ [\log(O_t)] - 1.7039\ [\log(A_t^*)] \tag{4.5}$$

where

N_t = total annual new-car sales in year t

O_t = gap between target and existing stocks

A_t^* = index of the average generalized price in year t, 1967 = 1.00

As stated earlier, the derivation of target stock for use in the new-car sales equation would have been unnecessary if the model authors had used a conventional stock adjustment model. They need only have included in the new-car sales equation those variables determining target stock. Price, one determinant of target stock, does enter through the sales rather than the "target stock" equation. Thus, "target stock" and the "gap" as calculated by the model authors do not have the usual, clear economic interpretations.

4.3.3 Data Used in the Regression. The data used by the HSRI staff to estimate the coefficients were supplied by JFA and are listed in Table 4-9. The data for N_t were verified to be new-car registrations. The A_t^* data are contained in Table 4-12 and are an index of average generalized costs with 1967 equal to 1.00. The HSRI staff was unable to reproduce the O_t data, since some inputs for the target stock equations were not available. Hence the gap between the desired and existing stocks could not be verified.

An important observation about the data presented in Table 4-9 is that O_t, which is supposed to be the gap between the desired and existing stocks, is always considerably smaller than new-car sales. One hypothesis is that the difference between sales and the gap is due to the computation of desired stock from household data, omitting fleet autos. Examination of fleet sales and the stock of fleet autos in relation to this difference indicates that the failure to account for fleet autos is not the sole source of this difference. Another potentially contributing factor is JFA's use of a cross-section relation to estimate the desired stock time series.

4.3.4 Statistics and Interpretation. Table 4-10 presents the values of the coefficients of the new-car sales equation as estimated by JFA and the HSRI staff. A comparison shows that the estimates match very well. The signs of the constant and gap coefficients are, as expected, positive, so that a larger gap between target and existing stock will increase new-car sales. The negative price coefficient is also expected; an increase in price should decrease new-car sales.

The t-statistics show that the constant and price coefficients are significantly different from zero at the 1% level. The gap coefficient is not significant until approximately the 15% level. The Durbin-Watson statistic is 1.18. Using linear interpolation and the standard tables (Durbin and Watson 1951), it was found that the test for one period autoregression

TABLE 4-9

DATA USED IN NEW CAR SALES EQUATION

Year	log (N_t)	log (O_t)	log (A_t^*)
1960	6.8180	6.7406	.0515
1961	6.7675	6.6628	.0441
1962	6.8413	6.6797	.0350
1963	6.8783	6.7039	.0398
1964	6.9066	6.7265	.0249
1965	6.9691	6.7340	.0191
1966	6.9547	6.8048	.0043
1967	6.9221	6.7918	.0000
1968	6.9733	6.8728	-.0035
1969	6.9790	6.9067	-.0150
1970	6.9273	6.7986	-.0329
1971	6.9984	6.8666	-.0348
1972	7.0256	6.8312	-.0477
1973	7.0598	6.7638	-.0565

Data Source: Automotive News, Almanac Issue 1970.
Consumer Buying Indicators

Table Source: Jack Faucett Associates

TABLE 4-10

NEW CAR SALES EQUATION
ESTIMATED COEFFICIENTS AND STATISTICAL RESULTS

(Standard errors in parentheses)

Estimated equation: $\log(N_t) = a + b_0\,[\log(O_t)] + b_1\,[\log(A_t^*)]$

Sample Period 1960-1973	Constant	Coefficient of O_t	Coefficient of A_t^*	$\bar{R}^2$	SER	DW	DF	F
JFA	5.45746 (1.4240)	0.21779 (0.21002)	-1.7039 (0.44124)	.7408	--	--	11	19.58
HSRI	5.45746 (1.4240)	0.21779 (0.21001)	-1.70387 (0.44124)	.7415	0.0417	1.18	11	19.64

is inconclusive.

If the market adjustment process were complete in one period and no other explanatory variables were present, then one would expect a one-unit increase in the gap to generate a one-unit increase in sales. However, when the adjustment process involves more than one period and additional explanatory variables are introduced, a one-unit change in the gap would be expected to generate a less than one-unit change in sales. Under these conditions, previous period gaps and other explanatory variables would account for current period sales.

The new-car sales equation is estimated in log form and the coefficients can be interpreted as elasticities. However, note that a 1% change in the gap variable is not a 1% change in the stock of cars. Rather a 1% change in the gap variable is a 1% change in the number of autos needed to equate the desired and actual vehicle stocks. In this case, the elasticity of new-car sales with respect to the gap is 0.22. Thus, a 10% increase in the gap will lead to about a 2% sales increase. While the coefficient on the price variable can also be considered an elasticity, it should be cautiously interpreted. The price variable is an index that includes operating costs as well as purchase price, so that the elasticity is not comparable to those commonly estimated for retail prices. In addition, new-car prices also enter the new-car sales equation through the impact of scrappage on the gap (8).

The new-car sales equation can be considered a test of the model's maintained hypothesis that equilibrium is attained through JFA's one-period stock adjustment formulation. At the customary levels of significance, the null hypothesis that b_0 equals zero can not be rejected. Thus, statistical evidence does not support the inclusion of O_t as a statistically significant independent variable in the sales equation. Since the only information provided in the model on the importance of the stock adjustment variable is contained in this equation, and since that evidence does not support the maintained hypothesis, serious doubts are cast upon the particular stock adjustment process which is a cornerstone of the model (9).

4.3.5 Conclusions. The auto ownership per household equation could not be precisely reproduced by the HSRI staff, while the new-car sales equation was reproduced almost exactly. The new-car sales equation is flawed by the use of an unconventional stock adjustment process that results in the inappropriate estimation of target stock from cross-section data and an inadequate specification of the determinants of target stock.

4.4 The Market Shares Equation

JFA initially attempted to divide cars into classes by a classification scheme based on "roominess" or interior dimensions. However, data for this scheme were not readily available for the entire sample period. A search by JFA for another classification scheme that would divide classes in roughly the same manner as the roominess index yielded a weight index, defined as:

Class	Weight Index
S: Small	Under 3,050 lbs.
M: Medium	3,050 to 3,500 lbs.
L: Large	Over 3,500 lbs

While the division by this index did not perfectly match that of the roominess index, it was a close approximation as there were only six misclassifications out of the fifty-two models classifiable by both systems (Difiglio and Kulash 1976). JFA notes that the weight classification scheme is used only as a proxy for roominess in the future forecasts of the model. The weights associated with each class will change due to the use of lighter materials in the construction of cars, but the relative roominess of each class will remain approximately the same.

This classification scheme necessarily obscures differences among the cars of a class and neglects the consumers' preferences related to those differences. Luxury and economy cars of the same class have similar weights but differ in price and operating cost. In response to a price increase, a new-car buyer might switch from a luxury medium car to an economy large car, but the possibility of this type of shift is not taken into account in the model and lies outside of its fundamental logic.

4.4.1 Specification of the Equation. The market share of each class was modeled by JFA as a function of the prices of the three classes of cars and the prior-year market share of that size class. The price variables are indexes for each class of car, with 1967 equal to one. Each index is the generalized price of a class in year t relative to the average generalized price in year t, divided by a similar ratio for 1967.

For regression purposes, the Faucett model employs a logit formulation. The logit form ensures that each of the individual predicted shares will always be between zero and one, but not that the shares will sum to one. The logit form used is:

$$SH_t^C = \frac{e^a}{1 + e^a} \qquad (4.6)$$

where

SH_t^C = market share of class C at time t

a = a linear combination of explanatory variables for class C

e = the base of natural logarithms (e $\approx$ 2.718)

The above equation can be rewritten as

$$\frac{SH_t^C}{1 - SH_t^C} = e^a \qquad (4.7)$$

and taking the natural logorithm, as

$$\ln\left(\frac{SH_t^C}{1 - SH_t^C}\right) = a \qquad (4.8)$$

The explanatory variables are current-year prices and prior-year shares. Including the prior-year share dampens the impact of current-year prices on current market share of a class. A possible reason for including prior-year share is that market shares are also affected by prior-year automobile prices of the various size classes. Rather than using these prices, their joint effect is approximated by the instrument of lagged market shares. Since each year's market shares are assumed to be a function of current-year prices, the inclusion of prior-year market share in the market share equation brings in the effect of prior-year prices.

The model authors could have estimated separate equations for each of the three size classes. However, because of the small number of observations, they employed a system of dummy variables interacting with the price variables to develop a single equation format for estimation. The specific form of the equation including the dummy variables is:

$$\ln\left(\frac{SH_t^C}{1 - SH_t^C}\right) = a + b_0\ (D_1)\ Y_t^S + b_1\ (D_2)\ Y_t^M + b_2\ (D_3)\ Y_t^L \tag{4.9}$$

$$+ b_3\ (D_2)\ Y_t^S + b_4\ (D_3)\ Y_t^S + b_5\ (D_1)\ Y_t^M$$

$$+ b_6\ (D_3)\ Y_t^M + b_7\ (D_1)\ Y_t^L + b_8\ (D_2)\ Y_t^L$$

$$+ b_9\ (D_1)\ SH_{t-1}^S + b_{10}\ (D_2)\ SH_{t-1}^M + b_{11}\ (D_3)\ SH_{t-1}^L + u$$

where

Y_t^C	=	the price indexes of cars of class C in year t with 1967 = 1.0
SH_t^C	=	market share of class C in year t
SH_{t-1}^C	=	market share of class C in year t-1
D_1	=	dummy variable with a value of one for small-car observations; zero otherwise
D_2	=	dummy variable with a value of one for medium-car observations; zero otherwise
D_3	=	dummy variable with a value of one for large-car observations; zero otherwise
a, b_i	=	coefficients to be estimated
u	=	stochastic error term

In order to conserve degrees of freedom and to constrain some of the relationships between the classes, JFA made four assumptions. First, the cross-price coefficient between nonadjacent classes is assumed to be equal to zero. This means that the b_4 and b_7 coefficients are set equal to zero. The second assumption is that the coefficient of the prior-year share of a class is constant across all three classes ($b_9 = b_{10} = b_{11}$). In other words, the relationship between the prior-year share and the current-year share is assumed to be the same for all classes. The estimated coefficient depends on all three classes. An alternative is to let the coefficient differ across classes. This alternate specification would let each class's prior year share affect only its own current-year share. The model authors state that this alternate specification was not used because the constrained version performed better than the unconstrained version (Difiglio and Kulash 1976). The third assumption is that the constant term is the same for all three classes. The fourth assumption is that the stochastic disturbance is the same for all size classes.

JFA supported the first assumption with the following statement: "Two cross-price variables, small car prices on large automobile shares, have been omitted from the final specification because they almost invariably appeared with perverse signs and extremely low t-statistics. It was assumed, therefore, that the price elasticities between nonadjacent shares was zero" [sic] (Difiglio and Kulash 1976, p. 2-140). The assumption that the price elasticities between nonadjacent shares are zero will be shown to be incorrect and inconsistent with JFA's specification of the equation. As explained below, the price variables in the shares equations are indexes that depend on the prices of all three classes. A change in the price of one class must affect the price indexes of both of the other classes. Consider the omission of the large-car price index when determining the small-car share. The effect of the large-car price is not zero, but enters through the small- and medium-car price indexes. Each of the other two class prices enters through both its own price index and the price index of the other. In other words, the market shares equation implies that the prices of nonadjacent classes affect market shares differently than do prices of adjacent classes, but not that the nonadjacent class price effect is zero.

The equation estimated by JFA is:

$$\ln\left(\frac{SH_t^C}{1-SH_t^C}\right) = -4.1749 - 1.8660\ (D_1)\ Y_t^S - 2.0765\ (D_2)\ Y_t^M \tag{4.10}$$
$$- 0.4299\ (D_3)\ Y_t^L + 3.5450\ (D_2)\ Y_t^S$$
$$+ 3.5093\ (D_1)\ Y_t^M + 1.8117\ (D_3)\ Y_t^M$$
$$+ 0.2589\ (D_2)\ Y_t^L + 5.6428\ (SH_{t-1}^C)$$

4.4.2 Data Used in the Regression. Table 4-11 contains the data used in the regression, while Table 4-12 presents the data used by JFA in forming the price indexes and shares listed in Table 4-11. These data were furnished to the HSRI staff by JFA. The HSRI staff was unable to perform a complete verification of the data in Table 4-12 due to the time-consuming nature of classifying the original data by class of car. However, the translation of the data from the second table to the first was examined.

The price variables are indexes of the generalized prices shown in Table 4-12 and are calculated as follows:

$$Y_t^C = \left(\frac{X_t^C}{A_t}\right) \times \left(\frac{A_{1967}}{X_{1967}^C}\right) \tag{4.11}$$

where

Y_t^C = price index for class C in year t, 1967 = 1.0

X_t^C = generalized price of a car of class C in year t

A_t = average generalized price in year t

HSRI staff verified that the index was calculated properly from Table 4-12, but could not determine the method used to calculate the average generalized price in year t. The method used to calculate the average generalized price in Table 4-12 is not the same as that used in the

TABLE 4-11

DATA USED IN MARKET SHARE EQUATION

Small Car Class

Year	$\ln\left(\frac{SH_t^S}{1-SH_t^S}\right)$	Y_t^S	Y_t^M	SH_{t-1}^S
1964	-.823	.945	.940	.2954
1965	-1.1084	.970	.931	.3040
1966	-1.1809	1.057	.975	.2482
1967	-1.4077	1.000	1.000	.2349
1968	-1.5535	.938	.968	.1966
1969	-1.4300	.893	1.001	.1746
1970	-1.0172	.896	.985	.1931
1971	-.8317	.822	.975	.2656
1972	-.7419	.836	.913	.3033
1973	-.8540	.886	.921	.3226

Medium Car Class

Year	$\ln\left(\frac{SH_t^M}{1-SH_t^M}\right)$	Y_t^M	Y_t^S	Y_t^L	SH_{t-1}^M
1964	-1.6119	.940	.945	.871	.1971
1965	-1.3626	.931	.970	.928	.1663
1966	-1.1904	.975	1.057	.959	.2038
1967	-.9148	1.000	1.000	1.000	.2332
1968	-.9700	.968	.938	.960	.2860
1969	-1.2801	1.001	.893	1.039	.2749
1970	-1.2406	.985	.896	1.022	.2175
1971	-1.7632	.975	.822	1.028	.2243
1972	-2.4853	.913	.836	.980	.1464
1973	-2.1786	.921	.886	1.014	.0769

Large Car Class

Year	$\ln\left(\frac{SH_t^L}{1-SH_t^L}\right)$	Y_t^L	Y_t^M	SH_{t-1}^L
1964	.1377	.871	.940	.5075
1965	.1926	.928	.931	.5297
1966	.1278	.959	.975	.5480
1967	.0696	1.000	1.000	.5319
1968	.2027	.960	.968	.5174
1969	.3615	1.039	1.001	.5505
1970	.0404	1.022	.985	.5894
1971	.2019	1.028	.975	.5101
1972	.4075	.980	.913	.5503
1973	.4042	1.014	.921	.6005

Data Sources: Automotive News, Almanac Issue 1958-1975.
Society of Automotive Engineers, 1975
Passenger Car Fuel Economy Trends Through 1976

Table Source: Jack Faucett Associates

TABLE 4-12

NEW PASSENGER CAR MARKET DATA

Year	SMALL			MEDIUM			LARGE			Average Generalized Price ($67)
	Sales	Fuel Economy	Generalized Price ($67)	Sales	Fuel Economy	Generalized Price ($67)	Sales	Fuel Economy	Generalized Price ($67)	
1973	3,377,326	20.00	2,556	1,150,474	13.90	3,368	6,784,510	9.63	4,967	4,007
1972	3,063,823	19.26	2,460	730,410	13.30	3,405	5,703,579	10.12	4,897	4,088
1971	3,090,563	19.88	2,494	1,491,301	12.20	3,745	5,606,605	10.67	5,294	4,214
1970	2,251,831	18.61	2,729	1,902,961	13.30	3,798	4,325,281	10.66	5,284	4,233
1969	1,823,989	18.83	2,833	2,054,713	13.30	4,026	5,567,830	10.67	5,599	4,410
1968	1,703,111	18.55	3,054	2,682,320	13.30	3,996	5,371,157	10.83	5,310	4,527
1967	1,663,694	20.05	3,284	2,419,770	13.10	4,162	4,378,347	11.26	5,579	4,564
1966	2,116,029	15.26	3,508	2,100,725	13.90	4,099	4,791,728	11.11	5,406	4,611
1965	2,311,421	18.48	3,329	1,897,711	13.70	4,050	5,104,810	11.37	5,413	4,770
1964	2,228,803	18.36	3,287	1,219,275	13.70	4,142	3,884,034	11.71	5,145	4,834
1963	2,232,342	17.82	3,182	1,489,446	12.60	4,287	3,835,529	11.20	5,288	5,001

Data Sources: Sales - R. L. Polk data reported in Automotive News, Almanac Issue 1974.
Fuel Economy - Computed from T. C. Austin, R. B. Michael, and G. R. Service (E.P.A.), Passenger Car Fuel Economy Trends Through 1976.
Price - Computed from data reported in Automotive News, Almanac Issues 1963-1974.

Table Source: Jack Faucett Associates

computer program, which is a share-weighted average.

An examination of equation 4.11 reveals additional insight into the price index used in the market shares equation. Equation 4.11 can be rewritten as:

$$Y_t^C = \frac{\dfrac{X_t^C}{X_{1967}^C}}{\dfrac{A_t}{A_{1967}}} \qquad (4.12)$$

(Recall that all prices are in constant ($1967) dollar terms.) The ratio, X_t^C/X_{1967}^C, indicates the "real" change in the price of an automobile of class C. For example, a "real" increase would reflect improvements in quality as well as where a higher proportion of cars have additional components that become standard equipment (e.g., radio). Real changes also reflect mandatory regulatory add-ons such as safety and air pollution control equipment. The ratio, A_t/A_{1967}, is intended to indicate the "real" change in the price of the average automobile. Thus, the price index Y_t^C indicates the value in quantity/quality adjusted prices of a particular size-class automobile relative to the average automobile. The HSRI staff suggests that a more appropriate comparison would have A_t and A_{1967} equal the average price of the non-C size-class automobiles. That is, for example, small-car prices would be relative to the prices of medium and large cars. This average produces a more direct comparison between the size-class substitutes.

4.4.3 Statistics and Interpretation. Table 4-13 presents the results of the HSRI staff and JFA estimations of the regression coefficients. The coefficients from Table 4-13 are used to construct "separate" share equations, presented in Table 4-14. The signs of the coefficients are in accord with economic theory: an increase in the relative price of a car of class C will decrease the market share of class C, while an increase in the relative price of a car in an adjacent class will increase the market share of class C. It should be remembered that the cross-price coefficients of nonadjacent classes are assumed by the model authors to

TABLE 4-13

MARKET SHARES EQUATION
ESTIMATED COEFFICIENTS AND STATISTICAL RESULTS

(Standard errors in parentheses)

Estimated equation:

$$\ln\left(\frac{SH_t^C}{1-SH_t^C}\right) = a + b_0\ (D_1)\ Y^S + b_1\ (D_2)\ Y^M + b_2\ (D_3)\ Y^L + b_5\ (D_1)\ Y^M + b_6\ (D_3)\ Y^M + b_8\ (D_2)\ Y^L + b_{12}\ SH^C_{t-1}$$

Sample Period 1963-1973	Constant	b_0 Coefficient of (D1) Y^S	b_1 Coefficient of (D2) Y^M	b_2 Coefficient of (D3) Y^L	b_3 Coefficient of (D2) Y^S	b_5 Coefficient of (D1) Y^M	b_6 Coefficient of (D3) Y^M	b_8 Coefficient of (D2) Y^L	b_{12} Coefficient of SH^C_{t-1}	$\bar{R}^2$	SER	DW	F
JFA	-4.1749 (1.3983)	-1.8660 (1.0526)	-2.0765 (3.4069)	-0.4299 (1.6217)	3.5450 (1.4913)	3.5093 (1.6586)	1.8117 (2.0076)	0.2589 (2.3472)	5.6428 (1.0248)	.927	0.2203	2.3907	47.185
HSRI	-4.1749 (1.3983)	-1.8660 (1.0526)	-2.0765 (3.4071)	-0.4299 (1.6215)	3.5450 (1.4913)	3.5092 (1.6586)	1.8117 (2.0077)	0.2590 (2.3476)	5.6428 (1.0249)	.927	0.2203	2.39	47.186

TABLE 4-14

MARKET SHARE EQUATIONS

$$SH_t^S = 1/(1 + e^{-[-4.1749 - 1.8660 (Y_t^S) + 3.5093 (Y_t^M) + 5.6428 (SH_{t-1}^S)]})$$

$$SH_t^M = 1/(1 + e^{-[-4.1749 - 2.0765 (Y_t^M) + 3.5450 (Y_t^S) + .2589 (Y_t^L) + 5.6428 (SH_{t-1}^M)]})$$

$$SH_t^L = 1/(1 + e^{-[-4.1749 - .4299 (Y_t^L) + 1.8117 (Y_t^M) + 5.6428 (SH_t^L)]})$$

equal zero. That is why no large-car price variable appears in the small-car market share equation and vice-versa.

The differences between the JFA estimates and the HSRI estimates are small and appear only in the fourth decimal place.

The t-statistics indicate that the b_1, b_2, b_6, and b_8 coefficients are not different from zero at the 10% level of significance. These coefficients are, respectively, the own-price coefficient for medium-car share, the own-price coefficient for large-car share, the cross-price coefficient for medium-car price on the large-car share, and the cross-price coefficient for large-car prices on medium-car share. The own-price coefficients are significant only at relatively high error levels, but are retained by JFA for theoretical reasons: the price of a car should affect its share of new-car sales. The cross-price coefficients, also significant only at high error levels, are retained because the model authors wanted each share to be affected by adjacent class prices.

The F-statistic of 47.19 indicates that as a group, the coefficients are significantly different from zero at the five percent level. The high F-statistic together with relatively low t-statistics would be a classic symptom of multicollinearity. The multicollinearity may be rooted in the poor specification of the shares equation. It may be argued that only one price index need be taken into account in determining each share, since all three prices enter into each index. As a group the estimated coefficients may produce a reliable forecast. However, the equation will not measure the individual impacts, via specific coefficient values of policies that single out a particular size class for a tax or rebate, because of the equation's inability to isolate the effect of a change in a single variable.

4.4.4 Normalization of Shares. While the logit specification produces share estimates that are between zero and one, a normalization procedure is required to ensure that the market shares sum to one. The explanation of this procedure in the model documentation (Difiglio and Kulash 1976, 1977) implies that the normalization procedure was as follows (henceforth referred to as simple normalization):

$$SH_t^{C*} = \frac{SH_t^C}{\sum_{C=1}^{3} SH_t^C} \tag{4.13}$$

where

SH_t^C = the market share of class C at time t as estimated by the equation

SH_t^{C*} = share after normalization

The computer program of the model uses another procedure. The model authors state (Jack Faucett Associates 1976b, p. 16) that because the demand for large cars is relatively price inelastic (i.e., consumers of large cars are less responsive to changes in price and operating cost than are consumers of other size classes of cars) the large-car share is determined first and the original estimate of large-car share dominates the normalization process as shown below (henceforth referred to as JFA normalization):

$$SH_t^{L*} = .8\ (SH_t^L) + .2\ \left(\frac{SH_t^L}{\sum_{C=1}^{3} SH_t^C}\right) \tag{4.14}$$

$$SH_t^{M*} = \left(\frac{SH_t^M}{SH_t^S + SH_t^M}\right)\ (1 - SH_t^{L*}) \tag{4.15}$$

$$SH_t^{S*} = 1 - SH_t^{L*} - SH_t^{M*} \tag{4.16}$$

Equation 4.14 calculates the normalized large-car market share as a weighted average (.8 and .2 are the weights) of the large-car share as estimated by the share equation and the simple normalized large-car share. Equations 4.15 and 4.16 split what remains after the large-car share is subtracted, according to the simple normalization process.

The model authors' explanation for this normalization process is illogical. An inelastic demand for large cars does not imply an inelastic large-car market share, and it is the share that is relevant. Consider the following extreme example. Suppose large-car sales are completely price inelastic, and, ceteris paribus, never vary. Also, sales of smaller cars are very price elastic. It follows that large-car share might vary widely with changing prices due to the changes in total sales that result from changes in sales of smaller cars. In fact, the large-car share apparently varies somewhat less than the other two shares over the sample period. The model does not, as a result of the smaller variation, predict large-car share more accurately than the other shares, as measured by mean square error (see Table 6-1). Thus, the validity of the procedure remains dubious.

The selection of the weights for equation 4.14 is not clearly explained. The documentation states that a series of test runs was made and that the .8/.2 division was "optimal." Without supporting statistics, the weights cannot be readily evaluated nor can any credence be given to this claim. If the estimate of large-car share (or any other class share) were determined to be the most accurate, then it seems reasonable that the other shares should be normalized to it without the need for weights.

The procedure for the normalization of shares substantially affects the model's outputs, sometimes producing anomalous results. This is shown in Section 7.0, Sensitivity Analysis of the Demand Block.

4.4.5 Conclusions. The market shares equation was reproduced exactly. However, there are problems with its specification, estimation, and use.

(1) The "cross-price" terms left in the equation are irrelevant variables. The inclusion of irrelevant variables increases the variance of all of the estimated coefficients; that is, it decreases the precision of the estimation.

(2) The market shares equation is formulated such that the constant term, the coefficient for the lagged market share variables, and the stochastic error term are the same for all three shares.

(3) Multicollinearity causes the estimated values of the coefficients to be imprecise, as indicated by the large variances of the least squares estimators. More uncertainty about the exact value of the coefficients means more uncertainty about the impacts of proposed policies.

(4) The normalization procedure used to ensure that the market shares

sum to one appears to be unjustified.

4.5 Vehicle Miles Traveled Equation

One of the major objectives of the Faucett model is to forecast the gasoline requirements of the automobile fleet. The model contains an equation that estimates aggregate vehicle miles traveled (VMT). This estimate is combined with the subfleet fuel economy ratings and VMT estimates by age of car to produce a forecast of gasoline consumption.

4.5.1 Specification of the Equation.

The model authors selected variables affecting VMT based on general degree of predictability and on sensitivity to energy conservation legislation (Difiglio and Kulash 1976). Consumer income, total cars in use, the fuel cost of operating a vehicle, and the number of consumer spending units (household population) were the variables selected. At least one important variable is omitted, family composition. Since number of adults and marital status of family head are important determinants of VMT, and there is a trend towards more one-adult households, a VMT equation without a family composition variable is unlikely to predict well in the future (Lansing and Hendricks 1967).

JFA estimated the VMT equation to be (10):

$$\begin{aligned} VMT_t/HHLD_t = & -52979.8 + 15087\,[\log(DI_t/HHLD_t)] \\ & + 6337.7\,(Autos_t/HHLD_t) \\ & - 2204.24\,[\log(100 \times CPM_t)] \end{aligned} \tag{4.17}$$

where

$VMT_t\,/HHLD_t$	=	vehicle miles traveled per household in year t
$DI_t\,/HHLD_t$	=	real disposable income per household in year t in 1967 dollars
$Autos_t\,/HHLD_t$	=	total cars in use per household on January 1 in year t

CPM_t = real fuel cost per mile in year t in 1967 dollars

4.5.2 Data Used in the Regression. The data used by the HSRI staff in estimating the equation are shown in Table 4-15. The HSRI staff verified household and autos per household data. Disposable income per household and CPM data could not be verified due to the lack of documentation on the specific sources.

4.5.3 Statistics and Interpretation. The HSRI and JFA estimates of the coefficients appear in Table 4-16. A comparison of the results shows that the estimates are close. The signs of the coefficients are as expected.

The Durbin-Watson statistic of .46 indicates the presence of autocorrelation. However, even with autocorrelation, the least squares estimates of the coefficients are unbiased, though not efficient, in the absence of additional violations of the classical statistical assumptions.

4.5.4 Annual Miles Traveled per Automobile by Age. Gas consumption cannot be predicted using the VMT equation alone since annual fuel consumption will depend on the distribution of VMT among different class vehicles of each vintage in the fleet. When the VMT equation is used to forecast, it is implicitly assumed that the distribution of cars across subfleets is the same as the average over the sample period. To the extent that this assumption is false, the forecasts will be less accurate. Information on the VMT distribution cannot be obtained from the VMT equation. Therefore, JFA developed another equation to provide the annual miles traveled per automobile by age. This equation is described briefly in the documentation (Jack Faucett Associates 1976b). JFA estimated the following relationship:

$$AMT_M = 17.9729 - 9.57841 \, [\log(M)] \tag{4.18}$$

TABLE 4-15

DATA USED IN VEHICLE MILES TRAVELED EQUATION

Year	$\frac{VMT}{HHLD}$	$Log(\frac{DI}{HHLD})$	Log (100 CPM)	$\frac{Autos}{HHLD}$
1954	9609	3.83187	.39445	.886
1955	10202	3.85150	.39794	.918
1956	10395	3.86058	.40824	.958
1957	10648	3.86291	.40654	.976
1958	10811	3.85619	.38917	.994
1959	11169	3.87081	.38739	1.014
1960	11138	3.86753	.39094	1.017
1961	11288	3.87466	.37840	1.045
1962	11487	3.88508	.37107	1.048
1963	11677	3.89730	.36736	1.080
1964	12068	3.91971	.35984	1.102
1965	12299	3.93777	.36922	1.119
1966	12753	3.95381	.37291	1.142
1967	12939	3.96483	.37658	1.161
1968	13249	3.97257	.37017	1.166
1969	13657	3.97520	.36736	1.189
1970	14051	3.98457	.35411	1.199
1971	14497	3.99167	.34439	1.211
1972	14794	3.99835	.33041	1.220
1973	14899	4.01649	.34830	1.230
1974	14391	4.016825	.57519	1.282
1975[a]	14812	4.013806	.60746	1.329

a. estimated

Data Sources: Federal Highway Administration. Highway Statistics, Platt's Oil Price Handbook and Almanac 1975. Editors, and Automotive News Almanac, Issues 1958-1975.

Table Source: Jack Faucett Associates

TABLE 4-16

VMT EQUATION
ESTIMATED COEFFICIENTS AND STATISTICAL RESULTS

(Standard errors in parentheses)

Estimated equation: $VMT_t/HHLD_t = a + b_0\ [\log(DI_t/HHLD_t] + b_1\ (Autos_t/HHLD_t) + b_2\ [\log(100 \times CPM_t)]$

Sample Period 1954-1975	Constant	Coefficient of log ($DI_t/HHLD_t$)	Coefficient of ($Autos_t/HHLD_t$)	Coefficient of log ($100 \times CPM_t$)	$\bar{R}^2$	SER	DW	DF	F
JFA	-52979.8 (14492.1)	15087. (4281)	6337.7 (2307.1)	-2204.24 (794.12)	.9767	257.235	0.4614	18	294.43
HSRI	-52979.5 (14494.1)	15087. (4281)	6337.7 (2307.1)	-2204.25 (968.60)	.9767	257.237	0.46	18	294.51

where

AMT_M = annual miles traveled per automobile at age M

M = age in years of the vehicle; 13 for the 11+ group

Table 4-17 presents the data used in the regression. It is based on cross-section data from 1969. To account for cars older than eleven years, the miles-traveled figure for the eleven years old and older group was assumed to be the average for thirteen-year-old cars.

The data in Table 4-17 were taken from The Nationwide Personal Transportation Study (U.S. Department of Transportation 1972, p.8). Using 1969 cross-section data, that report presented estimates of average annual miles traveled per automobile by model year of the newest car in the household. This classification obscures the average vehicle miles traveled per vehicle by age of vehicle for multi-car households. The correct interpretation of the data presented in that report is unclear because of the handling of the multi-car households. It is unclear whether the Transportation Study authors reported the average VMT of only the newest car in a household or the average VMT for all vehicles in a multi-car household and classified that average under the newest car in the household. In either case, the interpretation of those data by JFA is incorrect: the average number of miles traveled by automobiles of a certain vintage reported by Transportation Study authors is not the average for all vehicles of that vintage. For example, 16,000 is not the average number of miles traveled by all 2-year-old automobiles. The HSRI staff has not determined the impact of the use of these data.

The HSRI and JFA estimates of the coefficients are presented in Table 4-18. Since JFA did not report any descriptive statistics, a comparison can only be based on the published coefficients and those used in the program. The program uses -9.57841 instead of the published -9.57481 for the age coefficient; this difference is probably due to a typographical error in the published report.

The purpose of this regression equation is essentially to determine VMT estimates for vintages not available in Table 4-17. The equation is

TABLE 4-17

ESTIMATED ANNUAL MILES TRAVELED PER AUTOMOBILE
BY AGE OF CAR IN 1969

Age of Car in Years	Thousands of Miles Traveled Per Car
1	17.5
2	16.1
3	13.2
4	11.4
5	11.7
6	10.0
7	10.3
8	8.6
9	10.9
10	8.0
11 and older	6.5

Source: U.S. Department of Transportation, Federal Highway Administration. 1972. The Nationwide Personal Transportation Study, Report No. 2, p. 8, Table 1.

TABLE 4-18

ANNUAL MILES TRAVELED PER AUTOMOBILE BY AGE EQUATION
ESTIMATED COEFFICIENTS AND STATISTICAL RESULTS

(Standard errors in parentheses)

Estimated equation: $AMT_M = a + b\ [\log(M)]$

1969 Cross Sectional Data	Constant	Coefficient of log(m)	$\bar{R}^2$	SER	DW	DF	F
JFA Published	17.9729	-9.57481	--	--	--	--	--
JFA Program	17.9729	-9.57841	--	--	--	--	--
HSRI	17.9728 (0.69457)	-9.57822 (0.90662)	0.9171	0.9521	2.77	9	111.613

estimated using eleven vintage observations and is used to extrapolate the annual miles traveled for fourteen vintages. A problem is that strong "second wind" observations are commonly seen in the VMT-by-age data, as in the ninth year of Table 4-17. A single variable equation such as equation 4.17 cannot capture this sort of nonlinearity (11).

Total miles traveled in a particular year can be computed by summing over all age groups:

$$\text{Kmiles}_t = \sum_{M=1}^{14} \text{Miles}_M$$

where

Kmiles_t	=	total miles traveled by all cars in year t
Miles_M	=	total vehicle miles traveled by all cars M years old

Kmiles_t, however, may not equal VMT as predicted by the VMT equation. As the aggregate prediction from the VMT equation is thought to be more accurate than Kmiles_t, the mileage estimated for each age group is adjusted by multiplying Miles_M by the ratio of the VMT prediction to Kmiles_t. In mathematical notation:

$$\text{MMiles}_{Mt} = \text{Miles}_M \times \text{VMT}_t/\text{Kmiles}_t \qquad (4.19)$$

where

MMiles_{Mt}	=	adjusted miles traveled by cars of age M in year t

The MMiles_{Mt} are then used in computing gasoline consumption.

4.5.5 Conclusions. The VMT equation was reestimated exactly by the HSRI staff. The annual miles traveled per automobile by model year (AMT) equation was closely reproduced. Due to a misinterpretation of data, the AMT equation may have been estimated with inappropriate data.

The specifications of the VMT and AMT equations were found to be inadequate, due to omitted variables.

4.6 Summary of Analysis of the Demand Block

The HSRI staff successfully reestimated the scrappage, new-car sales, market shares, VMT, and the annual miles traveled per automobile by age equation. The attempt to reproduce the autos per household by income equation was unsuccessful.

Examination of the demand block and the reestimation of the equations brought to light several points:

- The published documentation was inadequate in two respects. Although the basic theory behind the model was discussed adequately, the authors failed to explain some of the assumptions made in the process of moving from the original data to estimated coefficients. The documentation displayed discrepancies as exemplified by differences among reports or between the documentation and the computer program in the value of some coefficients.

- The Faucett model was innovative in its attempt to maintain the automobile stock by class and vintage subfleets, and in its development of scrappage rates for each subfleet. However, the estimated coefficients of the scrappage equation were found to be unreliable. Also, the procedure for deriving scrappage rates by class is unjustified.

- The target stock equation omits relevant explanatory variables and as a result is thought to be unreliable. The new-car sales forecasts theoretically depend on the target stock and, thus, are critically affected. The statistical evidence does not support the inclusion of the stock adjustment variable in the new-car sales equation, casting serious doubt upon the particular stock adjustment process employed.

- The market shares forecasts are likely to be unreliable. These forecasts are based on restrictive assumptions that are at best only partially correct and on a highly questionable normalization procedure. Unreliable shares forecasts could cause significant distortions in the evaluation of the effectiveness of various policy options.

- The inadequate specifications of the VMT and AMT equations are likely to impair the model's accuracy in forecasting.

5.0 COMPUTER IMPLEMENTATION OF THE MODEL

5.1 Introduction

This section discusses a variety of points regarding the computer implementation of the model. The objective is to discuss the operation of the computer program in light of the established model structure and the prior estimation of the econometric equations. In some cases, the details of particular calculations are only described; in other cases, problems are pointed out.

There are a number of problems with the implementation of the model that are not necessarily programming errors but are unexplainable anomalies that cause inconsistencies in simulations. Some of these problems occur when indexed variables are created from real variables by multiplying and dividing by various constants. The source and purpose of some of these constants are not documented and the use of these not always warranted.

5.2 The Faucett Model Program

The computer program of the Faucett model received by HSRI is written in FORTRAN IV, is entirely self-contained, and is usable on any computer with little, if any, modification. (A listing of the computer program of the "8/77" version of the model appears in Appendix G.) Operation of the computer program is relatively straightforward. The user, interacting with the program via a computer terminal, is prompted for a set of input parameters: a fuel economy policy, the parameters describing the policy (excise taxes, rebates, penalties, and standards), and the price of gasoline over the simulation period. The calculations are then done and the results are printed out.

Some comments about the Faucett model program, as received by HSRI, are in order. The program is inefficiently written and inflexible in that many basic parameters can not be changed without rewriting the entire program. Because of its unsophisticated method of data input, it is easy for the user to make errors. It appears that not all of the options in the program as received were fully tested; specifically, the No-Policy option caused the program to "bomb out" because of a minor and correctable error. The program was set up to simulate only the "future" period (1976 through 1990 or 1995). To test the behavior of the model under various conditions and to compare its predictions with actual experience, the model must be modified to run over a historical period (in this case 1963 through 1973). Both 1974 and 1975 are excluded from the historical and future periods because of limitations in available data (12).

The HSRI staff has developed a program specifically designed for evaluating and exercising econometric models, called HEMS, or the HSRI Econometric Model Simulator. HEMS is flexible in that it allows one to set up a model with alternative sets of equations, with the ability to change coefficients and exogenous input data. A model may be run over periods of varying length and from different starting points. Many types of experiments may be performed on the full model or on submodels consisting of one or more equations.

In order to facilitate the analysis of the Faucett model, the Faucett model program was rewritten to be compatible with HEMS. This rewriting process preserved the sequence and logic of the equations, the values of the coefficients and the exogenous input data, and the division of the program into subroutines. The new version of the program allows the predicted values of many variables to be seen that formerly were only internal to the program. Before proceeding with the analysis, the HSRI staff assured themselves that this new version produced exactly the same results as the original.

For those familiar with the Faucett model program, it may be helpful to know how this program was rearranged on HEMS. (Interested readers unfamiliar with the program should refer to Jack Faucett Associates 1976a, b.) The functions of the MAIN program and most of those of the POLICY subroutine are carried out by the use of HEMS; these include the input of data and the output of results. The SETPR, FECOST, and HFN routines are referred to in this report as the Automobile Industry/Policy

Block. The RETIRE, SHARE, VMTS, and GASCON routines make up the Automobile Demand Block. In rearranging the program for HEMS it was found that the results of calculations done in the TOTAL routine (average generalized price with lagged market share weights) are not used anywhere in the rest of the program.

5.3 Lagged Excise Taxes/Rebates

Recall from Figure 3-2 that the excise taxes levied in each year are those specified for the previous year. This has various implications depending on which of two options the model user chooses. If the model user chooses to input an array of excise taxes and rebates for all or most of the forty MPG categories, then the lagged, or previous year, values will be used to determine current year automobile prices and fuel economies (through the generalized-cost-plus-taxes algorithm described in Section 3.2.1). The model user must input the array accordingly.

The program also contains an option (in the POLICY subroutine) that will set up a table of excise taxes and rebates for the user, according to parameters provided by the user. This table is constructed so that the taxes increase at an increasing rate as the fuel economy rating decreases; while the rebates, if any are to be given, increase at an increasing rate as the MPG rating increases. When this option is used, the table is constructed so that the current year's parameters will ultimately be used for the current year's excise tax option in the generalized-cost-plus-taxes algorithm. Thus, the two options under the Excise Tax/Rebate policy option differ in timing. The reason for the discrepancy between the two options is unknown.

5.4 Scrappage Rates by Class

As noted in Section 4.2.3, scrappage rates are calculated for each of the forty-two subfleets (three classes in each of fourteen vintages). For cars less than nine years old, the scrappage rates are assumed constant across classes and over time. The scrappage rate equation is used to predict scrappage rates for the three size classes of cars nine years old or older. This is accomplished by substituting into the equation, indexes of net prices of cars by class instead of the index of the average net price of cars.

After the size-class scrappage rates for a given year are developed, they are used to modify the scrappage rates for cars nine years or older for each vintage within each class. This modification occurs as follows:

$$SPG^{C}_{M,t} = \frac{SPG^{C}_{t}}{.248077} \times SR_{M}$$

where

$SPG^{C}_{M,t}$	=	scrappage rate for cars of age M (nine years or older) of class C in year t
SPG^{C}_{t}	=	scrappage rate for class C in year t as computed by the scrappage equation
.248077	=	linear average of scrappage rates for vehicles nine or more years old
SR_M	=	scrappage rate for cars M years old (comes from Table 4.1)

According to the documentation, .248077 "is a weighted average based on experience from 1961 to 1973" (Difiglio and Kulash 1976, pp. 2-172). This may be, but it is also the unweighted average of SPG data used in estimating the equation (the SPG covered the years: 1960-1967, 1969-1973). While the documentation may be wrong, the use of the unweighted average, .248077, is appropriate since the scrappage equation was estimated using the unweighted average.

5.5 Average Generalized Price and Average Generalized Price Index

The generalized price index variable used in forcasting new-car sales is calculated differently from the price variable used to estimate the coefficients of the sales equation. The price index in the computer code is calculated in the following manner:

$$A_t^* = \frac{A_t}{A_{1967}} \times \frac{4059}{A_{1975}}$$

where

A_t^*	=	index of average generalized price, 1967 = 1.0
A_t	=	average generalized price in year t
A_{1967}	=	average generalized price in 1967, which is equal to 4564
A_{1975}	=	average generalized price in 1975
4059	=	average generalized price in 1975

The model authors constructed this index "to calibrate the equation to reflect known 1975 values" (Jack Faucett Associates 1976b, p. 17).

Multiplying and dividing by the 1975 average generalized price should have no effect, since A_{1975} and 4059 should cancel each other out. But A_{1975} as it is calculated in the computer program equals 4140.9. The source of the difference between these values is not documented. The need for the 1975 calibration is not clear. The effect of the calibration is to reduce the index of average generalized price in year t by about two percent. This decrease in the price variable increases the forecast of new-car sales above what it would be without the calibration.

The values of average generalized price, A_t, used in calculating the generalized price index in the computer program, have the shares of the size classes as weights, as would be expected. However, for the estimation of the new-car sales equation, the index was calculated with values of average generalized prices that did not use shares as weights (see Table 4-12). The HSRI staff could not derive the method used to produce those values, even after lengthy consideration; it is even unknown to the model authors. Those values are, of course, crucial to the construction of the model. This incompatibility between the average generalized price values calculated by the program and those values used in the regression of the new-car sales equation contributes to poor predictions of new-car sales, as shown in Section 6.0.

5.6 Target Stock

The target stock forecast enters the computer program as a previously calculated series. All of the computations including the use of the auto ownership per household information are done not in the program, but outside it by the model authors. This procedure obscures the actual process by which target stock is calculated and makes it difficult to analyze this process. The computer program could have included the computations by which target stock is determined from variables describing the distribution of population across income brackets, auto ownership per household characteristics, and total population, as shown in Figure 2-3.

As the program stands, examining the effects of changes in income distribution and population on target stock requires that the user recalculate target stock and revise the program's income and population variables.

Table 5-1 contains the values of target stock as provided in the computer program, the annual changes in absolute terms, and the annual growth rates. Since some of the population forecast data are available only for five-year intervals, the intermediate years must be interpolated. This explains the constant growth rates for the first two five-year periods. Over the 1985-1990 period there are three different growth rates; for the 1991-2000 period, growth in target stock is assumed constant at 3,636,766 per year.

The probable source of the different growth rates over the period 1985-1990 is that a typographical error found its way into the computer program. The target stock value for 1986 is 121,883,480 instead of 123,883,480. When this error in the millions column is corrected, the growth rate over the 1986-1990 period is constant and equal to the 1988-1990 growth rate given in Table 5-1. This error is also present in the most recent versions of the Faucett model. Such a typographical error would be very damaging to the model's forecasts of 1986 and 1987 and would also affect later forecasts of scrappage and gasoline consumption.

TABLE 5-1

TARGET FLEET DATA*

Year	Target Stock	Differences Between Years	Growth Rate
1975	91,062,400		
1976	94,501,650	3,439,250	.0378
1977	98,070,800	3,569,150	.0378
1978	101,774,750	3,703,950	.0378
1979	105,618,590	3,843,840	.0378
1980	109,607,600	3,989,010	.0378
1981	111,897,800	2,290,200	.0209
1982	114,235,850	2,338,050	.0209
1983	116,622,750	2,386,900	.0209
1984	119,059,520	2,436,770	.0209
1985	121,547,200	2,487,680	.0209
1986	121,883,480	336,280	.0028
1987	126,264,670	4,381,190	.0359
1988	128,691,630	2,426,960	.0192
1989	131,165,240	2,473,610	.0192
1990	133,686,390	2,521,150	.0192
1991	137,323,156	3,636,766	.0272
1992	140,959,922	3,636,766	.0265
1993	144,596,688	3,636,766	.0258
1994	148,233,454	3,636,766	.0252
1995	151,870,220	3,636,766	.0245
1996	155,506,986	3,636,766	.0239
1997	159,143,752	3,636,766	.0234
1998	162,780,518	3,636,766	.0229
1999	166,417,284	3,636,766	.0223
2000	170,054,049	3,636,766	.0219

*Target stock values are those that appeared in the computer program of the versions received by the HSRI staff. They are different from the values in Jack Faucett Associates (1976b).

5.7 Modification of New-Car Sales Prediction

In the version of the Faucett model received by the HSRI staff in August 1977 which forms the basis of this model assessment, the forecasts from the new-car sales equation were multiplied by a variable called "DRI." This variable improves the accuracy of the model's new-car sales forecasts (see Section 6.0). The values of the variable range from .69 in 1976 to 1.03 in 1985. In the computer program, total new-car sales is multiplied by "DRI" after new-car sales for each of the 3 classes are added to the subfleet variables. Thus, the "DRI" adjustment has no effect on the subsequent equations of the model--VMT and gasoline consumption--or on the behavior of the model in subsequent periods.

In communication with the HSRI staff the model authors indicated that the purpose of the DRI variable was to adjust the model's forecasts of new-car sales to be equal to the forecasts of a Data Resources Incorporated (DRI) model of automobile demand. They indicated that the DRI variable was incorporated into the model for a special application and was inadvertently left in the version of the model sent to HSRI. The model authors were not aware of the incorporation of the DRI variable in the model's computer program that was sent to HSRI or of the improper use of the variable in the program until it was brought to their attention by the HSRI staff. Although the inclusion of the DRI variable in the program sent to HSRI was a mistake acknowledged by the model authors, the HSRI staff, nevertheless, performed simulations on the model with and without the DRI variable. This was done because other researchers also have the model version that includes the DRI variable.

A version containing the DRI variable has been incorporated into the Transportation Energy Conservation (TEC) Model used by the U.S. Department of Energy (Jack Faucett Associates, Inc. 1978, pp. F-26, F-28). Sparrow (1979) of Purdue University has performed a study that involved the TEC version of the Faucett model. The important point raised by these examples is that a model user must understand the inner workings of the specific version of the model being used or risk being misled.

5.8 Market Shares Modifications

The use of the market share equations in the computer program is not straightforward. While the equations are kept intact, the determination of the price and prior-period share variables involves a process not clearly described by JFA. The small-car-share forecasting procedure illustrates the problem.

5.8.1 Generalized Price Indexes. In the computer program, the small-car price variable is computed in the following manner:

$$Y_t^S = 1.3898 \times \left(\frac{X_t^S}{A_{1975}}\right) \times \left(\frac{3010}{X_{1975}^S}\right)$$

where

Y_t^S	=	indexed generalized price for small cars relative to average generalized price, in year t, 1967 = 1.0
1.3898	=	average generalized price of all cars in 1967, divided by the generalized price of small cars in 1967
X_t^S	=	generalized price of small cars in year t
A_{1975}	=	average generalized price in 1975
X_{1975}^S	=	generalized price of small cars in 1975
3010	=	This value is not documented, but it is thought by the HSRI staff to be an estimate of the generalized price of small cars in 1975. It is not the same as the program's calculation of X_{1975}^S, which equals 2999.3.

It is not clear from the documentation why JFA included both X_{1975}^S and

3010 in the equation; if both are the generalized price of small cars in 1975, then there is an unexplained discrepancy. If the two values were equal, the Y_t^S variable could be simplified:

$$Y_t^S = 1.3898 \times X_t^S / A_{1975}$$

But the small-car price variable used to form the data for the estimation of the market shares equation (see subsection 4.4.2) can be written as:

$$Y_t^S = 1.3898 \times X_t^S / A_t$$

A comparison of the above two equations suggests that $A_t = A_{1975}$. That is, the average generalized price used in the determination of market shares is assumed to remain constant and equal to the average generalized price of 1975 over all periods for which the program is predicting market shares. This assumption was also used in the determination of the medium- and large-car price variables. The validity of this assumption is questionable. The trend of average generalized price from 1963 to 1973 has been significantly and continuously downward, as shown in Table 4-13. This trend cannot continue indefinitely and may have bottomed out in 1973. As the government pressures the automakers to increase fuel economy, reduce emissions, and improve safety, the prices of cars should increase because of increased research, development, and capital costs. These increased prices are evident in the Industry/Policy Block part of the model, where the prices of cars increase in response to the policies. This suggests that the average generalized price of cars will not remain constant, and hence the above assumption is inconsistent with the rest of the model.

Given that the average generalized price is a function of market shares and that the market shares equations use by-class generalized price indexes to forecast, the use of current period market shares in the determination of by-class generalized price indexes would require a simultaneous equation system. The model authors chose not to use that type of system. An examination of the computer program indicates that a variable average generalized price based on the previous-year market share may have been intended for use in the by-class generalized price indexes. While the program calculates such a price (in the TOTAL subroutine), it is not used. Instead, the indexes are calculated using a constant 1975 average generalized price.

5.8.2 Modifications to Lagged Market Shares. A second problem related to the market share calculations in the computer program involves the calculation of prior-year share. Referring again to the example of small cars:

$$SH^{S}_{t-1} = \frac{N^{S}_{t-1} + N^{S}_{1975}}{2}$$

where

SH^{S}_{t-1} = small-car share in period t-1 used to determine small-car market share in year t

N^{S}_{t-1} = small-car share as calculated in year t-1

N^{S}_{1975} = small-car share in 1975

That is, the size-class market share is predicted with the value of the prior-year share variable being an average of the prior-year share and the share in 1975. This construction forces the value of the prior-year market share variable to be closer to the 1975 market share. The reason for this procedure is unexplained.

5.9 VMT Prediction

The coefficients of the VMT equation were estimated using automobiles per household on January 1 of each year. In the computer program, VMT is calculated using total automobile stock as of December 31 of each year. Since the number of cars in the total fleet at the end-of-year is generally higher by two to three million cars (3% - 4%) than at the beginning-of-year, VMT and gasoline consumption will be overestimated. To be compatible with the rest of the model, the VMT equation should have been estimated using end-of-year data for automobiles per household.

5.10 Annual Miles Traveled by Age of Car Prediction

In the model, the miles-traveled equation is used to predict the annual miles traveled by vehicles of each vintage, from one to thirteen years old and for a single age group containing all cars fourteen years and older, as follows:

$$\text{Miles}_M = \sum_{C=1}^{3} [F_M^C \times (17972.9 - 9.57841 [\log(M)])]$$

for M = 1 to 13, and

$$\text{Miles}_M = \sum_{C=1}^{3} [F_M^C \times (17972.9 - 9.57481 [\log(15)])]$$

for M = 14

where

Miles_M = total vehicle miles traveled by all cars M years old

F_M^C = number of cars of class C and age M

A possible error in the program involves the coefficient for the age variable in the Miles_M equation. The equation appears in the program twice, once to estimate Miles_M for each vintage from one to thirteen and once to estimate Miles_M for all cars fourteen years and older. In the first case the value of the age coefficient is -9.57841, while in the second case it is -9.57481. As noted in Section 4.5.4 the first value is closer to the HSRI staff estimates, and the second is probably a typographical error despite being the one reported in the documentation (Jack Faucett Associates 1976b, p. 19).

5.11 Gasoline Consumption

All five versions of the model use an accounting-type algorithm to calculate gasoline consumption based on the fuel economies and the estimated miles traveled of the forty-two subfleets (three classes for each of fourteen vintages). In all but the original version (Jack Faucett Associates 1976b), the prediction of aggregate gasoline consumption is increased by fourteen percent. Communication with the model authors indicated that this calibration was based on the results of a comparison of EPA and on-road fuel economies by Austin, Michael, and Service (1975). This adjustment was not made in the original version of the model because the discrepancy between EPA and on-the-road fuel economies was not an issue at the time the model was originally constructed.

While the model predicts fuel economy for new vehicles by size class, the subfleet fuel economies (for cars other than new) required to calculate gasoline consumption for the first year of the forecast period are supplied by the model authors. Four versions of the model (original, DL1, DL2-76 and DL2-77) have identical subfleet fuel economies. In the version analyzed by the HSRI staff (8/77), the subfleet fuel economies are approximately twenty percent higher than the respective fuel economies in any of the other versions. (Details on these various sets of fuel economies are presented in the next section.)

These observations indicate a possible inconsistency in the calculation of gasoline consumption in one or more versions of the model. In one version (8/77), subfleet fuel economies were higher than those in the other versions. But, aggregate gasoline consumption in all versions except the original is increased using the fourteen percent gasoline consumption adjustment factor. Users of the model are urged to determine what assumptions have been incorporated into the version being applied.

5.12 Fuel Economies

The concept of fuel economy is straightforward: the distance that consumes a specified amount of fuel. For the Faucett model, all fuel economies are in terms of miles per gallon (mpg). Measurement of vehicle fuel economy is less straightforward. Weather, road, driver, and vehicle conditions affect a vehicle's fuel economy. The U.S. Environmental Protection Agency (EPA) has standardized many of the conditions in an attempt to produce fuel economy ratings that are comparable across vehicles. For model builders and users, a standardized fuel economy test procedure applied consistently over time is ideal. However, the EPA has changed its test procedure over time (Austin, Michael, and Service 1975). Although EPA produces equations to translate fuel economies based on one test procedure into fuel economies comparable to those based on another test procedure, these equations introduce additional uncertainty into the model. Because model builders require a consistent set of fuel economies for the stock of vehicles, this increased uncertainty appears unavoidable. Nevertheless, the introduction of additional potential error of linking alternative fuel economy measurement procedures should be carefully considered.

The Faucett model authors used fuel economies from several sources to build the model. Construction of the Industry/Policy Block is based on the EPA fuel economy/cost relationships from Hittman Associates (1976). The portion of that report concerning fuel economies is based primarily on four sources (13). The Demand Block was constructed using EPA fuel economies from Austin and Hellman (1973) and Austin, Michael, and Service (1975). These fuel economies are listed in Table 4-12.

The dependence of the Faucett model on several sources of fuel economy data raises the issue of how the data were integrated in the construction of the model. If the sources referenced by Hittman Associates used nonstandard measurements of fuel economies, then consistent and appropriate integration may have been prohibitively expensive and instead simplifing assumptions were required. Even if those sources used EPA's measurements of fuel economies, there is the potential issue of integrating the different EPA fuel economy test procedures into the model's fuel economy/cost relationships. Furthermore, if the Industry/Policy Block was constructed in a consistent manner, then its compatibility with the Demand Block also needs to be ascertained. The HSRI staff did not examine the procedures involved in integrating the various fuel economy ratings into the model. The model user relying on the Faucett model to accurately predict EPA fuel economies is urged to review those procedures.

5.12.1. Fuel Economies for 1963-1973 Vehicles. The HSRI staff has identified three sets of fuel economies for 1963-1973 model year cars. The sources and calculations involved in determining these by-class fuel economies are generally undocumented by the model authors. An explanation for these variations may lie in the problems noted above. The first set of fuel economies is indicated in Table 4-12 and is the set used by the model authors in the estimation of the model's Demand Block equations. These fuel economies are also those used by the HSRI staff in performing the historical simulations with the model (see Section 6.0). This set of fuel economies was selected for the historical simulations because it was used to estimate the equations and because the other sets may have been adjusted to be compatible with the fuel economies estimated by the Industry/Policy Block. The second set of fuel economies is included in the model's computer program and is used to forecast post sample years in the original, DL1, DL2-76, and DL2-77 versions of the model. The third set is the one indicated in the 8/77 version of the model (the version analyzed by the HSRI staff). These fuel economies are about 20% higher than the respective fuel economies in the second set. The HSRI staff used the third set of fuel economies to perform the ex ante forecasting experiment discussed in Section 6.0. The third set was selected for the ex ante experiments because it was the set included in the computer program of the 8/77 version for simulations over the 1976-1990 period. The fuel economies contained in the three sets are presented together in Table 5-2.

It is important to note that the HSRI staff selected the various sets of fuel economies for used in the particular esperiments based on reasons associated with the origins of the sets rather than on the appropriateness of the values contained in the sets. Model users are urged to examine the alternative sets of fuel economies and select the set that is most appropriate for their needs.

TABLE 5-2

FUEL ECONOMY RATINGS OF NEW CARS, BY SIZE CLASS AND MODEL YEAR FOR THE HISTORICAL PERIOD, IN MILES PER GALLON

Model Year	Small			Medium			Large		
	8/77	Other	Samp.	8/77	Other	Samp.	8/77	Other	Samp.
before 1962	21.38			16.28			13.82		
1962	21.38	17.82		16.28	13.57		13.82	11.52	
1963	21.38	17.82	17.82	16.28	13.57	12.60	13.82	11.52	11.20
1964	22.03	18.36	18.36	17.82	14.85	13.70	14.58	12.15	11.71
1965	22.18	18.48	18.48	17.29	14.41	13.70	14.24	11.87	11.37
1966	18.31	15.26	15.26	17.11	14.26	13.90	13.90	11.58	11.11
1967	24.17	20.05	20.05	17.31	14.36	13.10	13.96	11.59	11.26
1968	22.36	18.55	18.55	17.31	14.36	13.30	13.68	11.35	10.83
1969	22.67	18.83	18.83	17.18	14.27	13.30	13.38	11.11	10.67
1970	22.46	18.61	18.61	17.48	14.48	13.30	13.40	11.10	10.66
1971	23.94	19.88	19.88	16.10	13.37	12.20	13.18	10.95	10.67
1972	23.21	19.26	19.26	16.69	13.83	13.30	12.81	10.63	10.12
1973	24.00	20.00	20.00	17.60	14.70	13.90	12.31	10.26	9.63
1974	22.96	18.81		17.37	14.23		12.20	9.97	
1975	25.39	20.81		19.81	16.23		14.61	11.97	

Note: "8/77" refers to the fuel economy ratings used in simulations with the version of the model that was the primary focus of this analysis. "Other" refers to the ratings provided with all other versions of the model (original, DL1, DL2-76, DL2-77). "Samp." refers to those fuel economy ratings used by JFA in the construction of sample period data for estimation of the model's behavioral equations.

5.12.2 Environmental Protection Agency (EPA) vs. On-the Road (OTR) Fuel Economies Ratings. A difference between the earlier versions (original, DL1, and 8/77) and the later versions (DL2-76 and DL2-77) is in forecasting new-car mpg's, on average and by class. The earlier versions produce mpg estimates that are unlabeled. These unlabeled (as to EPA or OTR) estimates are compared to fuel economy standards rated in EPA terms. Communication with the model authors indicated that the unlabeled mpg's reflect the uncertainty surrounding the EPA-OTR differences that existed during the development of those versions. As studies quantifying these differences became available, the model was modified. The DL2 versions reflect this growing awareness and are dependent on EPA-OTR relationships estimated by McNutt, Pirkey, Dulla, and Miller (1978).

In the DL2-76 computer program, the OTR and EPA fuel economies for 1977 and beyond are determined as follows:

$$FEOTR = FE/1.14$$

$$FEEPA = (FE/1.14 - 2.32)/.74$$

where

FE = the fuel economy determined by the model's generalized price minimizing algorithm (14)

FEOTR = on-the-road fuel economy

FEEPA = U.S. Environmental Protection Agency (EPA) rated fuel economy

The DL2-77 version is the same as DL2-76 version except that for 1978 and beyond, the EPA and OTR fuel economies are determined in the computer program as follows (variable definitions same as above):

$$FEOTR = FE/1.14$$

$$FEEPA = (FE/1.14 - 2.98)/.65$$

While the EPA-OTR relationships in the DL2-76 and DL2-77 versions were taken from McNutt et al. (1978), the 1.14 factor that converts FE to

FEOTR is undocumented. In conversations, the model authors provided information on this factor. Hittman Associates (1976) developed the technology/cost relations in the Industry/Policy Block using EPA fuel economies. However, these relations were estimated using pre-1975 data. Austin, Michael, and Service (1975) examined the relationship between EPA and OTR fuel economies for 1967 to 1973 year vehicles. The model authors used that information to derive a 1.14 multiplicative factor to convert OTR to EPA-rated fuel economies in the Faucett model. The question then arises why the 1.14 EPA-OTR factor is included along with the NcNutt et al. (1978) EPA-OTR relationships in the DL2-76 and DL2-77 versions of the model. The 1.14 factor is included in those versions because the Industry/Policy Block produces fuel economies rated in pre-1975 EPA terms that need to be converted to post-1975 terms for comparison with the automobile manufacturer's corporate average fuel economy standards.

FEOTR and FEEPA are produced solely as alternative estimates of new-car fuel economies. That is, the models' forecasts of variables other than mpg are dependent directly on FE, which is a fuel economy estimate rated in pre-1975 EPA terms.

However, the EPA-OTR relationships are used to modify the standards and penalties used by the Standard/Penalty option of the Industry/Policy Block to forecast the unlabeled fuel economies of new cars, FE (14). The modifications convert the standards and penalties, rated in EPA, into standards and penalties rated in FE terms. Thus, the EPA-OTR relationships affect all model forecasts under the Standard/Penalty option.

The Excise Tax/Rebate option is not modified to convert taxes (or rebates) from EPA terms into FE terms. Therefore, under that option, the model's forecasts, other than mpg, are not affected by the EPA-OTR relationships. Therefore, users of the DL2-76 and DL2-77 versions of the model should be aware that forecasts using the Standard/Penalty and Excise/Tax/Rebate options are not comparable.

5.13 Preparation of Actual Historical Data Needed for Simulation Experiments

While it was not difficult to modify the program to allow for simulations over the historical period, this sort of simulation cannot be done without the exogenous input data for the historical period required by the model. Since the model was never intended to be run over historical periods, the model authors never derived all of the data required for this purpose. However, most of the historical data needed for historical simulation runs were provided to the HSRI staff by JFA. Data not provided by JFA were derived by the HSRI staff, including the following three data series: (1) the number of cars by size class and vintage existing in the years 1962 to 1973, (2) the fuel economy ratings by class for model-year cars 1949 to 1962, and (3) the net prices of cars by class for model-year cars 1963 to 1973.

The HSRI staff calculated the number of cars by size class and vintage existing as of December 31 of each year based on the data in Table 4-2 that describe the subfleets by model year in each year as of July 1. The calculation process is described in Appendix B.

The fuel economy ratings by class were supplied (Table 4-12) by JFA for 1963 to 1973 model-year cars. For years prior to 1963 the HSRI staff assumed the fuel economy ratings to be 21.38, 16.28, and 13.82 for small, medium, and large cars, respectively. This was done since calculation of the fuel economy ratings is very time-consuming and because the paucity of data might have produced incorrect results.

The net prices of cars by class were calculated by subtracting the operating cost from the generalized prices by class. These calculations are also described in Appendix B.

The above discussion brings up an important issue: the appropriateness of building a policy analysis model that cannot be analyzed on the basis of generally available data. Some flaws in the model and its computer program will not be readily apparent to the policymaker who uses the model for forecasting without first performing historical simulations.

5.14 Summary

The execution of the Faucett model fails to live up to the potential of the design. More care is needed in estimating and programming the model.

The model was estimated as an entirely sequential, or recursive, system. Some relationships might have been modeled more accurately by use of simultaneous equations. There are points in the model where a system of simultaneous equations could have used predicted values for endogenous variables. The Faucett program was not written to facilitate this, and instead lagged values or constants were used as the endogenous variables.

It has been difficult for the HSRI staff to determine exactly what data were used to estimate each equation and if the data input to each equation for forecasting are consistent with the data used in estimation. The difficulty stems not merely from insufficient published documentation, but from the failure of the model authors to adequately record the model-building process.

The model authors apparently failed to test the model's ability to reproduce the values of behavioral variables for the period over which the model was estimated. This left undetected the inconsistencies between the model as it was estimated and the computer program that implements the model. Specifically:

- In the program the following variables are modified by constants without adequate explanation: aggregate gasoline consumption, lagged market shares, the average generalized price index, and the average generalized price by class indexes.

- Target stock enters the program as a previously calculated series. The process by which it is calculated is unclear. There is a typographical error in the future period values of this variable.

- The new-car sales forecasts are modified to agree with the DRI model forecasts.

- The VMT equation was estimated using beginning-of-the-year data for aggregate auto stock, but the program inputs end-of-the-year auto stock to the VMT equation. This error results in a tendency to overestimate VMT and gasoline consumption.

- The excise taxes and rebates used to calculate net car prices are sometimes lagged without apparent reason.
- There appears to be a typographical error in the miles-traveled-by-age-of-car equations.
- The method used to calculate the average generalized prices used in estimation of the new-car sales equation differs from the method used to calculate average generalized prices in the computer program.

Later versions of the program contain a number of changes, including new data for some exogenous variables, conversion factors for translating EPA fuel economy ratings into on-the-road-mileage equivalents, and new projections of the technological costs of improving fuel economy. None of these changes address the serious problems cited above.

6.0 FORECASTING BEHAVIOR

6.1 Introduction

The Demand Block forecasts eight key variables: new-car sales; scrappage; vehicle miles traveled (VMT); gasoline consumption; total cars in use; and market shares of small, medium, and large cars. This section employs the results of four forecasting experiments (also referred to as simulations) that compare actual and forecast values of the key variables to assess the forecasting behavior of the Demand Block, and a fifth experiment using the full model. In addition, the model's forecasts are compared to the forecasts of a naive time trend.

The first four experiments were run over the sample period, and are called ex post forecasts. Since the actual values over the sample period were used to estimate the Demand Block's equations, the ex post forecasts are expected to closely replicate the actual values. The fifth experiment extends beyond the sample period, and is called an ex ante forecast. Both ex post and ex ante forecasts provide benchmarks for judging the Demand Block's forecasting accuracy, because forecasts generally will be no more reliable in the future than in the past. The first experiment is over the sample period 1963-1973 (the sample period differs among the equations; this is the longest common period); the second and third are over the half periods 1963-1967 and 1968-1973, respectively. These three experiments were performed dynamically, in the sense that the model generated its own lagged values of the predicted variables when generating the forecasts. The fourth experiment seeks to determine if the model tends to accumulate errors as the length of the forecasting horizon is increased. The fifth experiment examines the full model's forecasting accuracy over the 1976-1978 period. (No forecasts were produced for the years 1974-1975 due to lack of data for exogenous variables and for target stock.)

The forecasting behavior of the full model was not studied in all of the experiments because the projected fuel economy-cost relationships of the Industry/Policy Block are inapplicable to the past. In place of the Industry/Policy Block, actual fuel economy ratings and net prices were exogenously input to the Demand Block for the experiments over the sample period (15). The ex ante forecasting experiment made use of the Standard/Penalty option, and depends on the fuel economy-cost relationships specified by the Policy Block for 1976, 1977, and 1978.

Since the Faucett model was not designed to be run over the historical period, it was required that the model be prepared so that historical "forecasts" could be obtained. The steps taken in this preparation are detailed in Section 5 and in this section. Furthermore, in simulating the model over the historical period, the HSRI staff eliminated the fourteen percent adjustment to aggregate gasoline consumption (see Section 5.11). As the fourteen percent adjustment may have been developed solely for postsample forecasting, the HSRI staff deemed it inappropriate for historical simulations. Inclusion of the fourteen percent adjustment factor would have increased the gasoline consumption forecasts which were generally overpredictions already (see Section 6.2).

Finally, a standard benchmark to compare the model's forecasting ability is provided by a naive time trend of the form $y = a + bt$, where y is the endogenous variable and t is the year for the prediction. Both sample and postsample period forecast comparisons are made between the model and time trend. Also, differences between the sample and postsample period forecasting accuracy of the time trend are compared with those differences produced by the model.

The results of the forecasting experiments are presented in graphs that compare actual and forecast values of the key variables, and in two types of tables. The first type of table has four headings labeled ACTUAL, FORECAST, ERROR, and %DIFF. ACTUAL refers to the historical (actual) values and FORECAST refers to the predicted values of the endogenous variables. ERROR refers to the difference between the actual and forecast values, while %DIFF refers to the percentage difference relative to the actual value. The second type of table presents summary statistics from the simulation experiments: the root mean square error (RMSE), the percentage RMSE (%RMSE), and a simulation R^2 (SIML R-SQ). RMSE is an average error of the predicted values and measures the accuracy of the forecast. The %RMSE is the RMSE as a percentage of the mean of the actual values of the variables over the forecast period, that is, 100xRMSE/meanACTUAL. The SIML R-SQ is a descriptive measure of the predictive accuracy of each equation as solved in the model simulation, that is, in generating forecasts. The interpretation of the SIML R-SQ is like that of R^2, except that the former may have negative values indicating that the forecast, or simulation, is very unreliable. Details concerning the construction and interpretation of the SIML R-SQ are presented in Appendix A.

As the reader interprets the results of the forecasting experiments he should be aware that the HSRI staff used, to the extent possible, data supplied by JFA. In the sample-period experiments, the JFA data used included both exogenous and "actual" data, with which the forecasts were compared. One variable not supplied by JFA was gasoline consumption by automobiles. Values of this variable were obtained from Federal Highway Administration publications. The reader should note that these data are estimates and, therefore, are subject to error. For the postsample experiments, "actual" data were obtained from the sources used by JFA in preparing their sample-period data. Gasoline price data which are exogenous were obtained from the U.S. Department of Energy.

6.2 Forecasting Experiment 1963-1973

The HSRI staff first ran the Demand Block to forecast over the sample period 1963-1973 with only those modifications required to adapt the computer program to HEMS. The results of the experiment are summarized by the error statistics in Table 6-1. Figures 6-1 to 6-8 compare actual and forecast ("JFA predicted") values graphically. (Detailed results are presented in Appendix C, Tables C-1 to C-8.)

Generally, high RMSEs and %RMSEs and low SIML R-SQs indicate inaccurate forecasts. To put the magnitude of the model's errors in perspective, another automobile sector model forecasting quarterly over a

TABLE 6-1

ERROR STATISTICS FOR THE WITHIN-SAMPLE PERIOD (1963-1973)

Dynamic Simulation of Original Model*

Variable	Mean Actual **	RMSE	% RMSE	SIML R-SQ
Sales	9,249,000	845,500	9.141	.4027
Scrappage	6,586,000	585,600	8.892	.4212
VMT (in billions)	820.8	27.33	3.330	.9483
Gas consumption (in millions of gallons)	59,780	3,798	6.353	.8615
Cars in use	74,040,000	1,202,000	1.623	.9777
Small car market share	.2576	.04412	17.13	.2007
Medium car market share	.1935	.05590	28.89	.2064
Large car market share	.5489	.06055	11.03	-2.359

* The error statistics presented here are based on the simulation labeled as JFA Predicted in Figures 6-1 to 6-8.

** Data Sources for Actuals:

- Scrappage and cars in use are from Automotive News 1975 Almanac Issue.
- Sales were supplied by JFA and are new registrations from Automotive News 1975 Almanac Issue.
- VMT and gasoline consumption are from the U.S. Department of Transportation Federal Highway Administration's Highway Statistics. Various issues 1963-1973.
- Market share data were supplied by JFA.

FIGURE 6-1

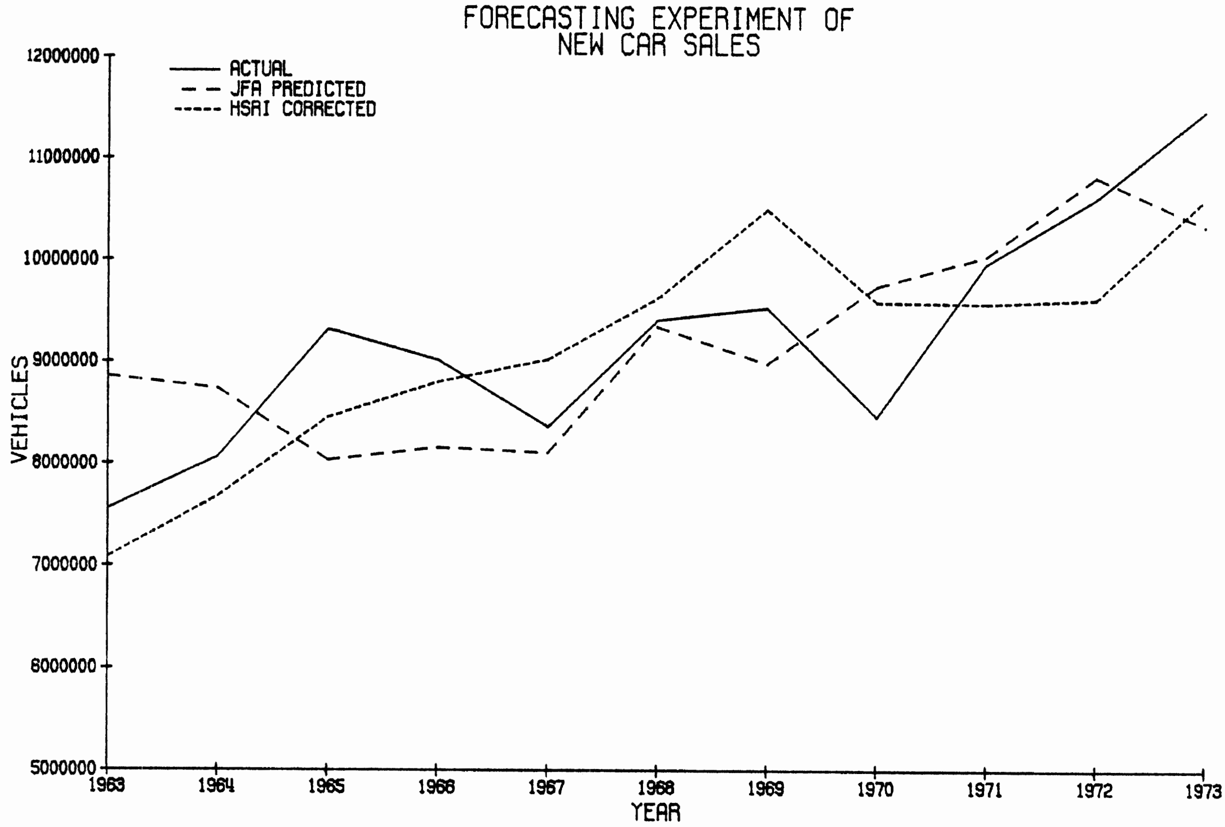


FIGURE 6-2

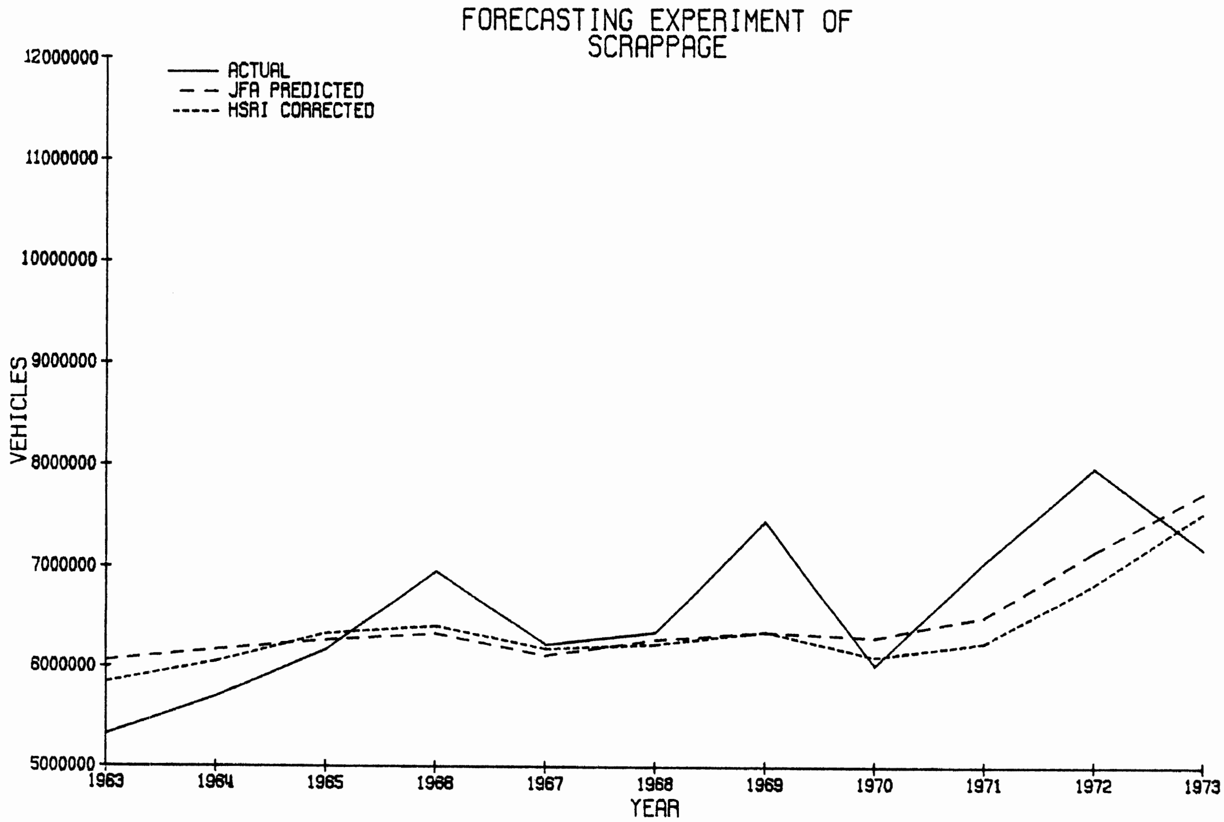


FIGURE 6-3

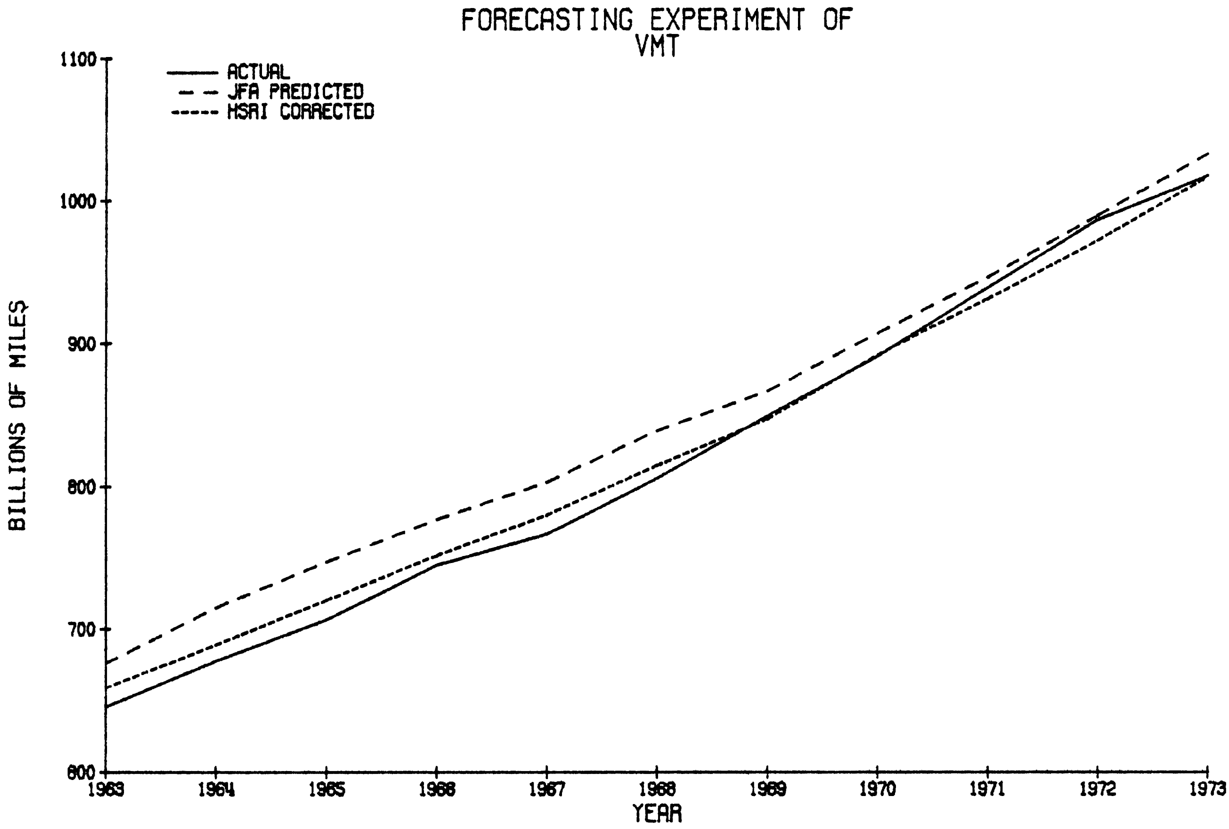


FIGURE 6-4

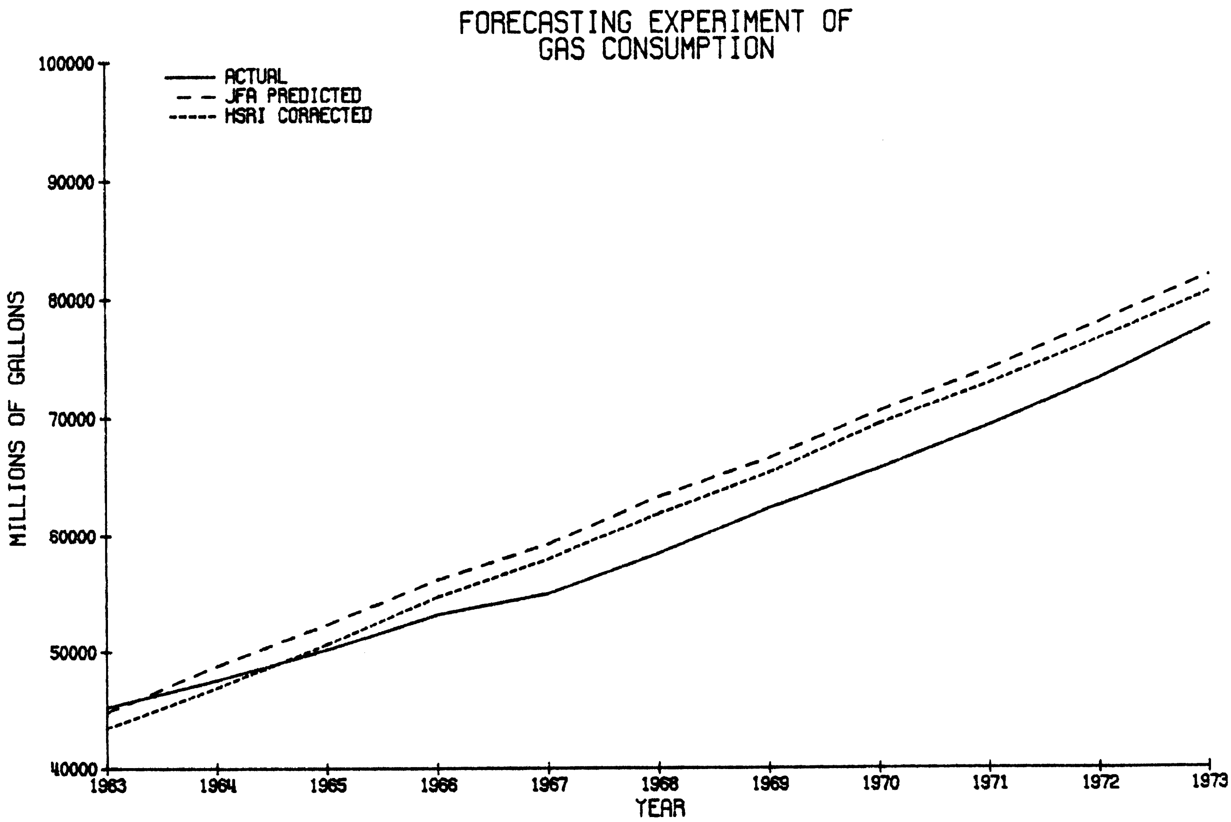


FIGURE 6-5

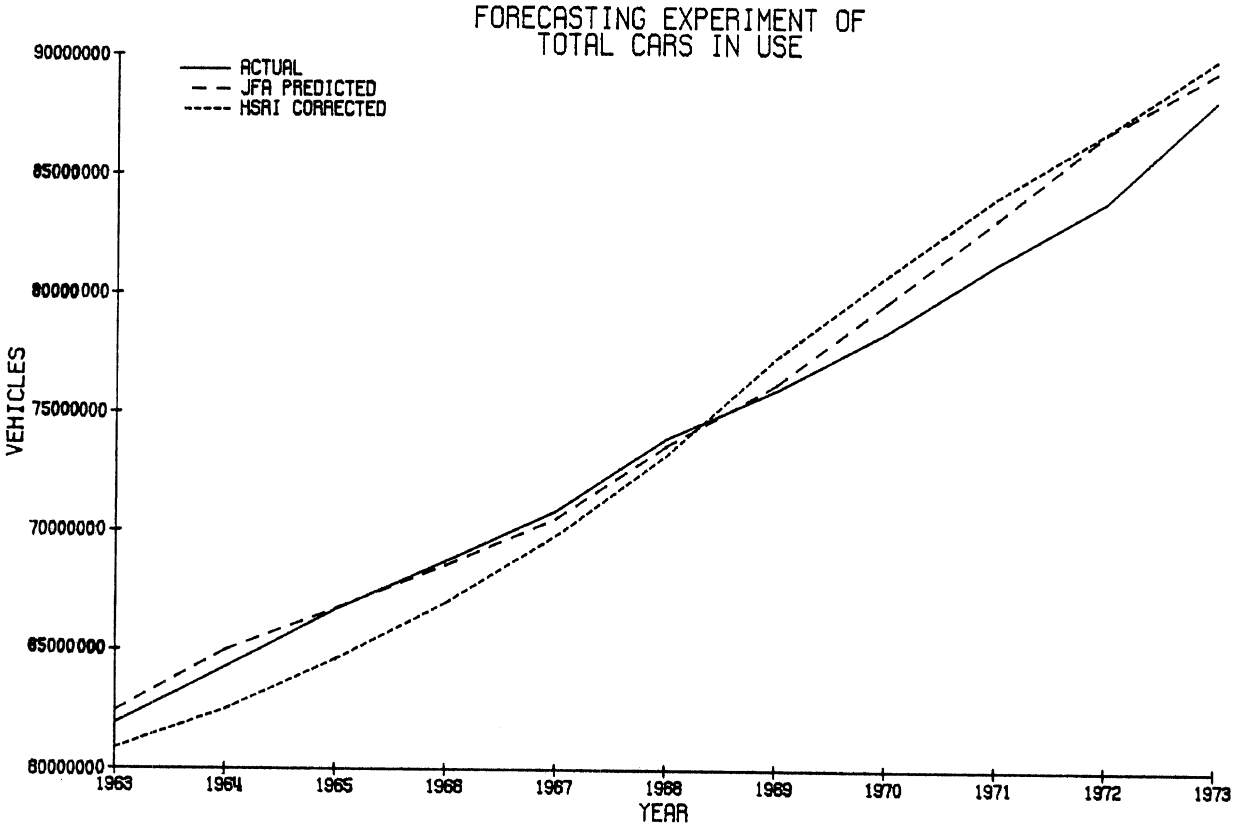


FIGURE 6-6

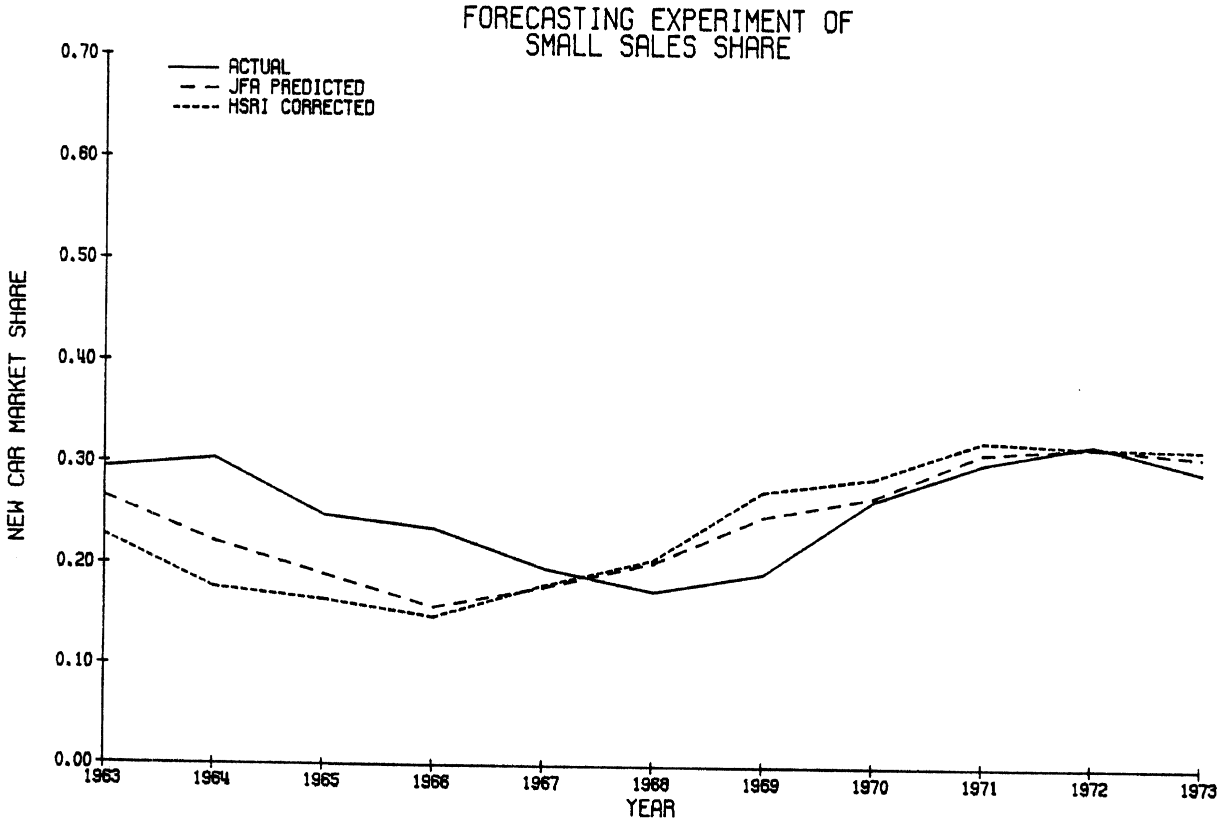


FIGURE 6-7

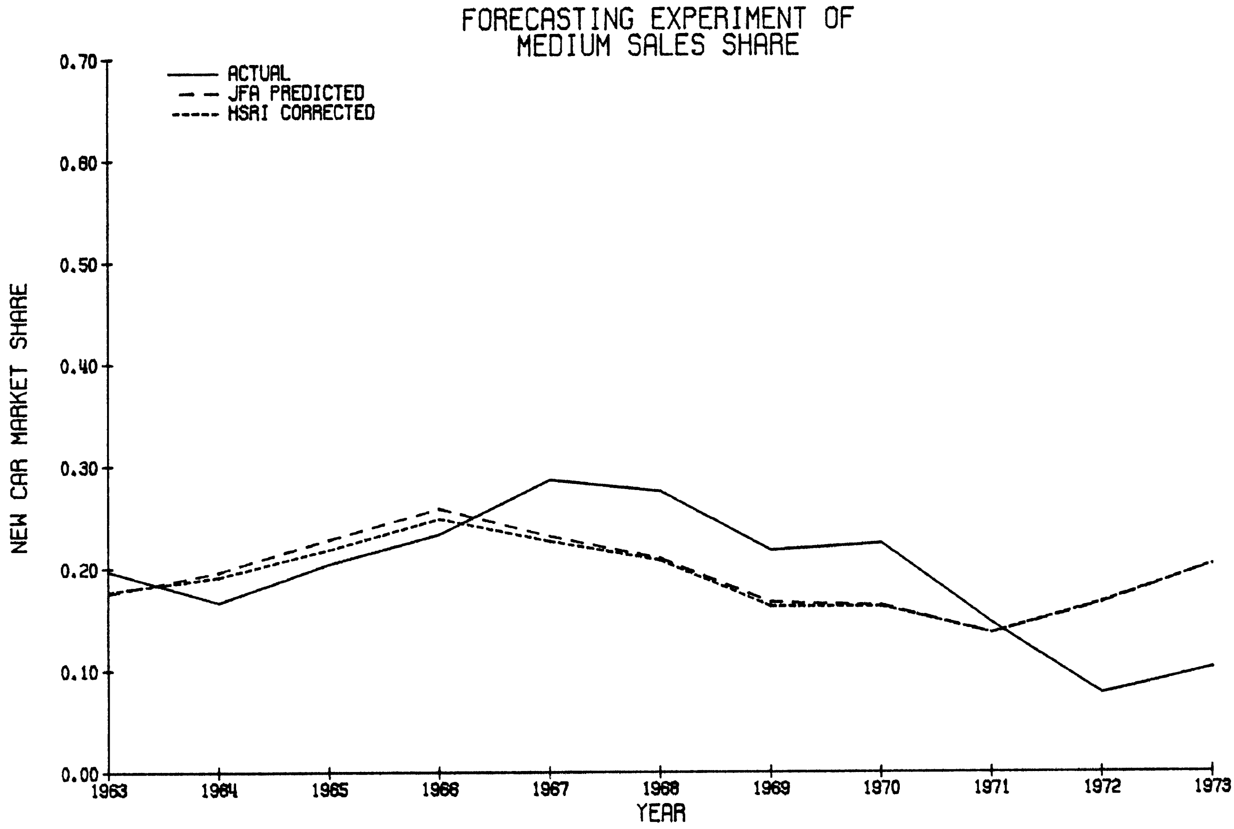
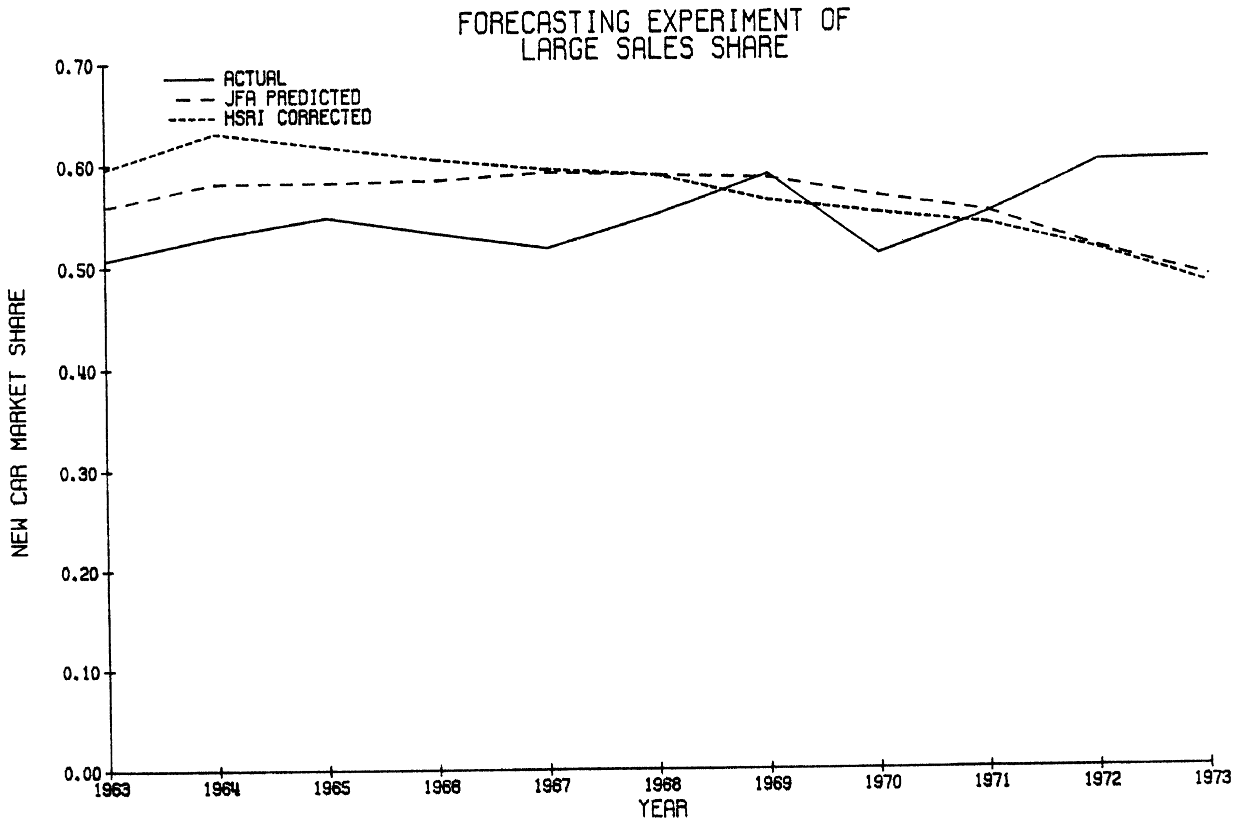


FIGURE 6-8



similar sample period (1961.4-1973.3) achieved %RMSEs of 3.9 percent for new-car sales and 0.3 percent for VMT (Luckey 1978). The Faucett model's forecasts of VMT and of gasoline consumption are biased upward. As can be seen from the graphs, both are consistently overpredicted. The cars-in-use forecast appears to be the most accurate, judging from the %RMSE, but considering the size of the year-to-year change in this variable relative to its level (less than 5%), a very small %RMSE is expected.

The sources of some of the forecasting errors can be traced. The market shares forecasts are among the least accurate. In modeling market shares, JFA assumed the future average generalized prices of cars to be constant and equal to the average generalized price in 1975 (4140.9). In running the model over the historical period, the HSRI staff likewise assumed the historical value of the average generalized price to equal the 1975 value, even though the actual average generalized prices of 1963 to 1971 model-year cars (Table 6-2) are higher than the 1975 value. The difference between average generalized prices during the historical period (1963-1973) and the average generalized price in 1975 was thought by the HSRI staff to be the most likely cause of large errors in predicting market shares over the historical period. If future average generalized prices are more closely approximated by the 1975 values, the reliability of the forecasts of the market shares over the historical period would then not be a good indicator of the reliability of the forecasts over the future. However, if the average generalized prices are not relatively constant in the future, and there is no strong presumption that they will be, then the market shares forecasts may be very unreliable.

To test the impact of the constant average generalized price assumption, the HSRI staff produced alternate forecasts with a variable average generalized price. In the market shares equation, average generalized price was calculated using lagged market shares. Market shares forecasts improved; but, the accuracy of the forecasts for other variables declined substantially and the %RMSEs for the market shares remained quite large. The HSRI staff speculates that simultaneous determination of market shares and average generalized price might

TABLE 6-2

AVERAGE GENERALIZED PRICES

YEAR	Average Generalized Price Used in Estimating the New Car Sales Equation as Supplied by JFA (1967 dollars)	Average Generalized Price by the Market Share Weighted-Average Method as Calculated by HSRI Staff (1967 dollars)	DIFF
1963	5,001	4,468	533
1964	4,834	4,413	421
1965	4,770	4,618	52
1966	4,611	4,655	-44
1967	4,564	4,722	-158
1968	4,527	4,556	-27
1969	4,410	4,722	-312
1970	4,233	4,272	-39
1971	4,214	4,217	-3
1972	4,088	3,996	92
1973	4,007	4,084	-77

produce better results. This would require a considerable change in the model's structure, however.

The inaccuracy of the forecasts of sales, VMT, and gasoline consumption partially derives from two errors. First, the average generalized prices used by JFA in estimating the new-car sales equation differ from those used in the computer program for forecasting. The former prices are calculated by a method that is not documented by JFA, while the method used in forecasting is to construct a weighted average of the generalized prices by class where the weights are the market shares. Table 6-2 compares the values for average generalized price as calculated by the HSRI staff, using the weighted-average method, with the values for average generalized price used by JFA to estimate the equation. The difference between the two calculations of average generalized price is large, and contributes to the errors in predicting new-car sales as shown later in this section. Second, the total stock (cars in use) values used to estimate the VMT equation were beginning-of-the-year figures. In forecasting VMT, end-of-the-year figures are used, thereby biasing the VMT forecast upward. Overprediction of VMT contributes to overprediction of gasoline consumption.

The forecasts of sales, VMT, and gasoline consumption can be improved by correcting the two errors discussed above. These corrections are relatively simple. To improve the prediction of new-car sales, the net prices of cars by class were changed so that the weighted average of generalized prices by class would equal the average generalized price used in estimating the new-car sales equation. This procedure is explained in Appendix B. To improve the prediction of VMT, the computer program was altered so that the total stock at the beginning of the year (lagged total stock) would be used in predicting VMT.

The HSRI staff expected that the changes made to net price by class would have two side effects. First, the changes to net price would produce new generalized prices, and in turn, generalized price indexes. Since the new indexes would differ from those used to estimate the market shares equation, the changes to net price were expected to increase the errors in predicting market shares. Second, changing net price would produce new net price indexes. As the scrappage equation was estimated using the average of the old net price indexes, the accuracy of the scrappage equation was expected to decrease also.

The forecasting experiment over the period 1963-1973 was repeated with the corrections outlined above. Figures 6-1 to 6-8 graph the new forecast values ("HSRI corrected") alongside the forecast values obtained prior to the corrections for comparison with the actual values. Table 6-3 presents the error statistics. (Detailed results are presented in Appendix C, Tables C-9 to C-16.) The forecasts of new-car sales, VMT, and gasoline consumption have lower %RMSEs. The upward biases in VMT and gasoline consumption are reduced. As expected, the market shares and scrappage forecasts are less accurate than in the uncorrected version.

To this point only the accuracy of the levels of the forecasts have been considered. One may also inquire as to the ability of the model to track movement in the variables, either general trends (long-run tendencies) or cycles (year-to-year ups and downs, not necessarily regularly occurring). The model's trend tracking ability is assessed by comparison with a time trend in Section 6.6. The Demand Block's ability to track cycles can be judged on the basis of how well the turns in the forecasts correspond to the turns in the actual data. This information is presented in Table 6-4. The HSRI corrections substantially improve the tracking of turns in new-car sales, but do less well in improving the tracking of the turns in size-class shares. The Faucett model tracks cycles most poorly for sales and the medium-car market share, and best for scrappage. For sales, the model forecasts only one of three upturns correctly, incorrectly forecasts upturns for both of the downturns, and incorrectly forecasts downturns for three of the five periods when there were no turns. The HSRI corrections improve the cyclical tracking primarily by dampening cyclical behavior. Cyclical behavior in the medium-size share is relatively poorly tracked because the model forecasts turns when none occurred and no turns when turns did occur.

The results indicate that the Demand Block's ability to track the historical behavior of some variables (particularly sales) improves with the modification of input data and the alteration of the computer program.

TABLE 6-3

ERROR STATISTICS FOR THE WITHIN-SAMPLE PERIOD (1963-1973)

Dynamic Simulation of Corrected Model*

Variable	Mean Actual**	RMSE	% RMSE	SIML R-SQ
Sales	9,249,000	722,300	7.810	0.5641
Scrappage	6,586,000	607,200	9.219	0.3778
VMT (in billions)	820.8	9.873	1.203	0.9933
Gas consumption (in millions of gallons)	59,780	2,693	4.505	.9304
Cars in use	74,040,000	1,913,000	2.584	0.9435
Small car market share	.2576	0.06358	24.68	-0.6593
Medium car market share	.1935	0.05640	29.15	0.1921
Large car market share	.5489	0.07414	13.51	-4.034

*The error statistics presented here are based on the simulation labeled as HSRI Corrected in Figures 6-1 to 6-8.

**See Table 6-1 for data sources.

TABLE 6-4

ABILITY OF THE MODEL TO TRACK CYCLICAL BEHAVIOR*

New-Car Sales

JFA Forecast

	Actual +T	Actual -T	Actual NT	
+T	1	2	0	3
-T	1	0	3	4
NT	1	0	2	3
	3	2	5	10

3 of 10

Corrected Forecast

	Actual +T	Actual -T	Actual NT	
+T	1	0	1	2
-T	0	1	0	1
NT	2	1	4	7
	3	2	5	10

6 of 10

Scrappage

JFA Forecast

	Actual +T	Actual -T	Actual NT	
+T	3	0	0	3
-T	0	2	0	2
NT	0	1	4	5
	3	3	4	10

9 of 10

Corrected Forecast

	Actual +T	Actual -T	Actual NT	
+T	3	0	0	3
-T	0	2	0	2
NT	0	1	4	5
	3	3	4	10

9 of 10

Small Share

JFA Forecast

	Actual +T	Actual -T	Actual NT	
+T	0	0	1	1
-T	1	1	0	2
NT	1	1	5	7
	2	2	6	10

6 of 10

Corrected Forecast

	Actual +T	Actual -T	Actual NT	
+T	0	0	1	1
-T	1	0	1	2
NT	1	2	4	7
	2	2	6	10

4 of 10

TABLE 6-4 Continued

Medium Share

JFA Forecast

	Actual +T	-T	NT	
+T	0	1	1	2
-T	0	0	1	1
NT	3	2	2	7
	3	3	4	10

2 of 10

Corrected Forecast

	Actual +T	-T	NT	
+T	1	1	1	3
-T	0	1	1	2
NT	2	1	2	5
	3	3	4	10

4 of 10

Large Share

JFA Forecast

	Actual +T	-T	NT	
+T	1	1	0	2
-T	1	0	1	2
NT	1	1	4	6
	3	2	5	10

5 of 10

Corrected Forecast

	Actual +T	-T	NT	
+T	1	0	0	1
-T	0	0	1	1
NT	2	2	4	8
	3	2	5	10

5 of 10

*This set of tables summarizes the model's ability to track turns in the sample data for sales, scrappage, and market shares. In each table there are three columns for actual behavior labeled +T (upturn), -T (downturn), and NT (noturn), and three similar rows for forecast behavior. The last number in each column (row) is the column (row) sum. Summing over either the column (actual) or row (forecast) sums yields the total possible number of turns, given in the lower right hand corner. The first three elements diagonal from upper left to lower right show matches between the forecast and the actual data. For example, reading down the first column of the new car sales JFA forecast matrix (upturns in actual new car sales), one upturn was correctly predicted, one upturn incorrectly predicted as a downturn, and one predicted as noturn. There were a total of three upturns in the actual data. (By coincidence there were also three upturns in the forecast, but two were predicted when downturns occur in the actual data.) Summing over the diagonal, one upturn and two noturns were correctly predicted for a total of three correct predictions from a possible ten.

However, achieving the improvements entails a loss of accuracy in forecasting market shares and scrappage. Therefore, the HSRI staff decided to conduct further experiments using the uncorrected (original JFA) version of the Demand Block.

6.3 Forecasting Experiments 1963-1967 and 1968-1973

Experiments were performed over the periods 1963-1967 and 1968-1973 to examine the forecasting behavior of the model in each half of the full sample period. These experiments were designed to test for differences in forecasting accuracy that may indicate economic and demographic changes in the two periods that were inadequately captured by the Demand Block. The statistical results are presented in Table 6-5. Figures 6-9 to 6-24 are graphs of actual and forecast values for the two periods.

The %RMSEs indicate that relative to the full period forecasts (1963-1973) some variables were more accurately forecast over the first half (1963-1967), and some over the second half (1967-1973). New-car sales, VMT, gasoline consumption, and small-car market share were more accurately forecast over the second half. Scrappage, cars in use, and the other two market shares were forecast more accurately over the first half. There is nothing special or unexpected about these results. More interestingly, the graphs reveal that the small-car market share was underpredicted, while large-car share was overpredicted over the entire first half. Small-car share was overpredicted over the entire second half. VMT was overpredicted in both halves, that is, upward biased. However, neither these nor any of the other results suggested specific economic and demographic differences betweeen the two halves of the sample period that were unaccounted for by the Demand Block.

The most important finding of these experiments is that gasoline consumption was more accurately forecast over both half-periods, than over the full period. The full-period forecast uses the forecast 1963-1967 values of the endogenous variables to generate the 1968-1973 forecasts, whereas the half-period forecast over 1968-1973 uses the actual 1963-1967 values to generate the 1968-1973 forecasts so that error accumulated in

TABLE 6-5

ERROR STATISTICS (1963-1973, 1963-1967, and 1968-1973)

Variable	Mean Actual			RMSE		
	63-73	63-67	68-73	63-73	63-67	68-73
Sales	9,249,000	8,460,000	9,906,000	845,500	955,100	839,800
Scrappage	6,586,000	6,076,000	7,012,000	585,600	486,000	616,600
VMT (in billions)	820.8	708.1	914.7	27.33	35.48	24.41
Gas Consumption (in millions)	59,780	50,250	67,720	3,798	2,561	1,703
Cars in Use	74,040,000	66,500,000	80,330,000	1,202,000	429,300	1,702,000
Small car market share	.2576	.2558	.2592	.04412	.05856	.03658
Medium car market share	.1935	.2173	.1737	.05590	.03347	.06263
Large car market share	.5489	.5269	.5671	.06055	.05435	.06754

DYNAMIC SIMULATION OF THE MODEL

Variable	% RMSE			SIML R-SQ		
Sales	9.141	11.29	8.477	0.4027	-1.265	.2238
Scrappage	8.892	7.999	8.793	0.4212	.2233	.1264
VMT (in billions)	3.330	5.010	2.668	0.9483	.3460	.8913
Gas Consumption (in millions)	6.353	5.098	2.515	0.8675	.4849	.9302
Cars in Use	1.623	0.6456	2.119	0.9777	.9818	.8761
Small car market share	17.13	22.89	14.11	0.2007	-1.173	.5747
Medium car market share	28.89	15.40	36.06	0.2064	0.3141	.2146
Large car market share	11.03	10.31	11.91	-2.359	-14.63	-3.118

FIGURE 6-9

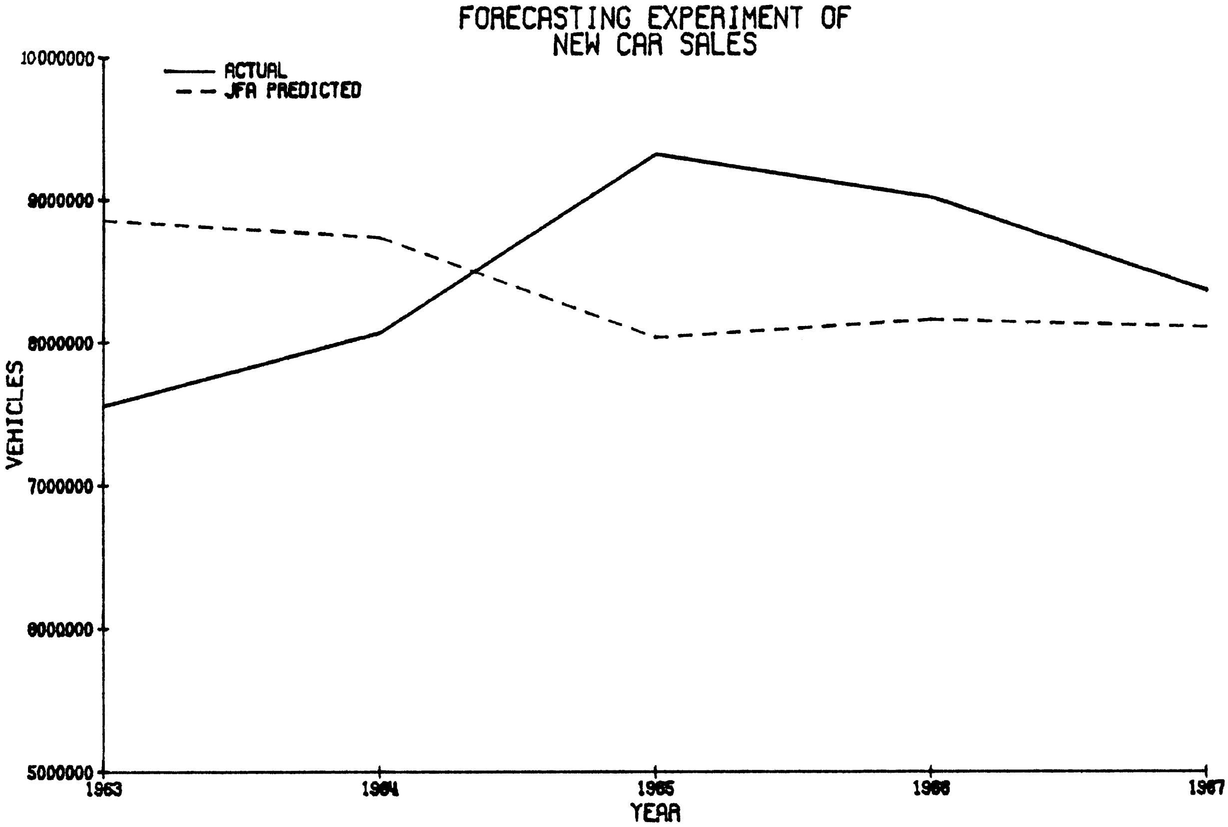


FIGURE 6-10

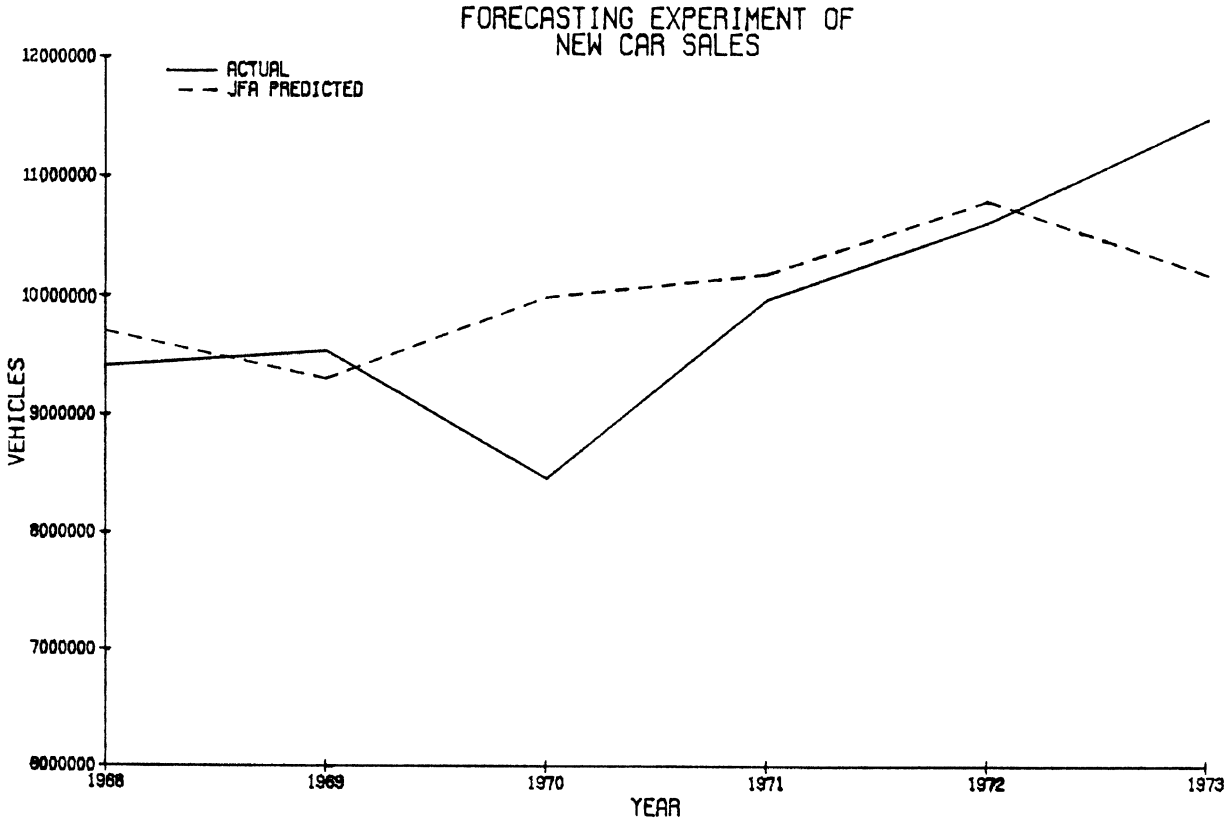


FIGURE 6-11

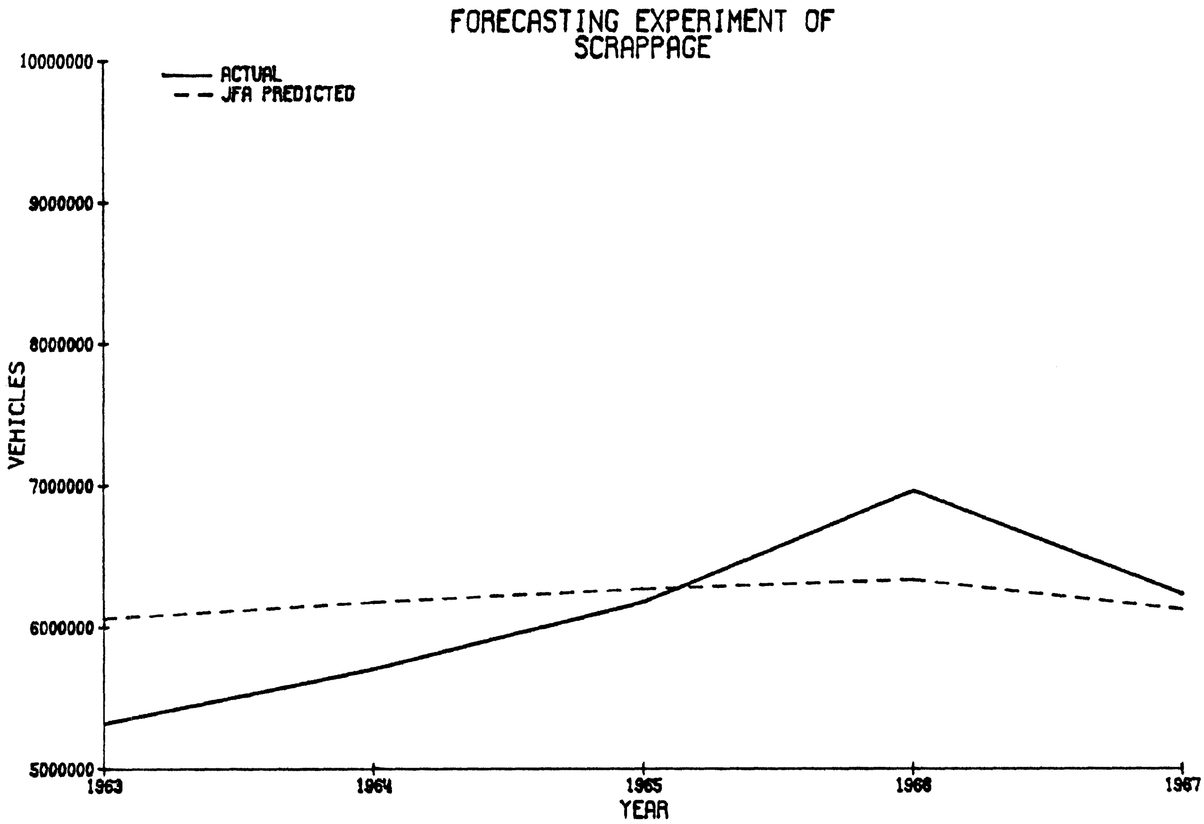


FIGURE 6-12

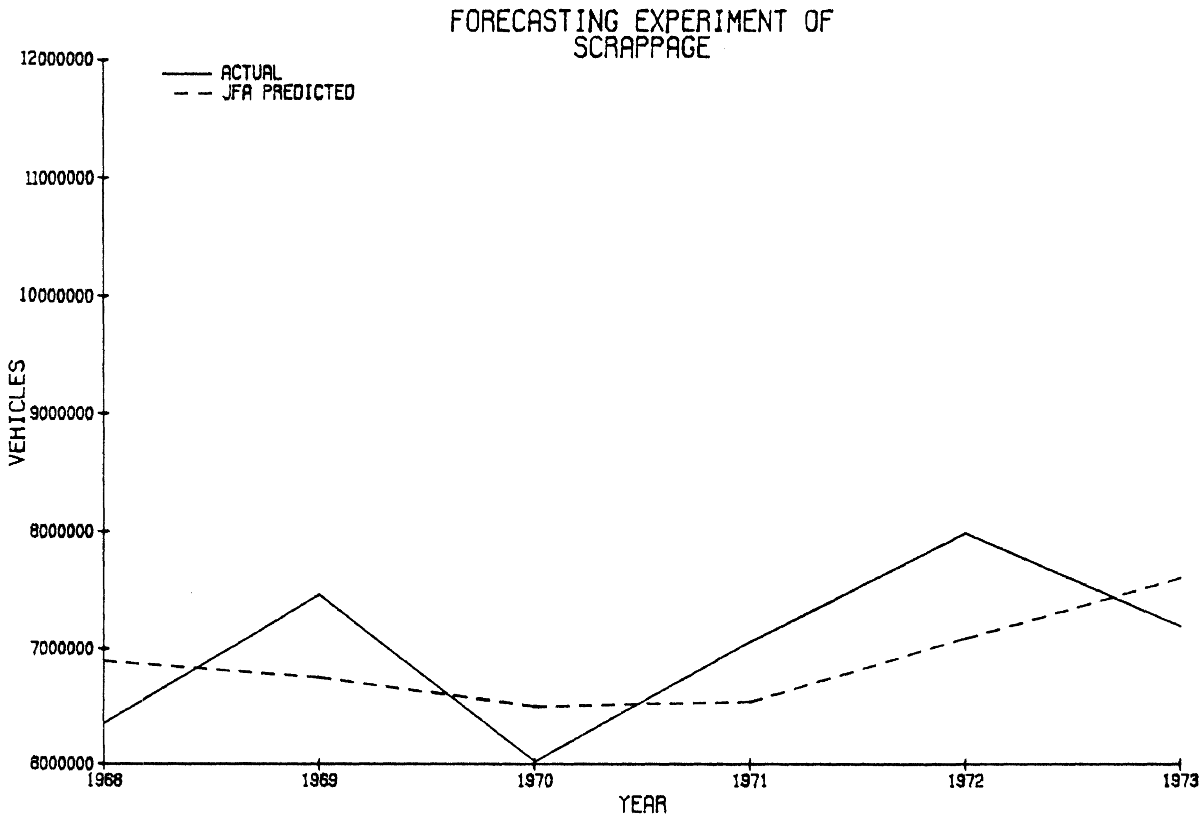


FIGURE 6-13

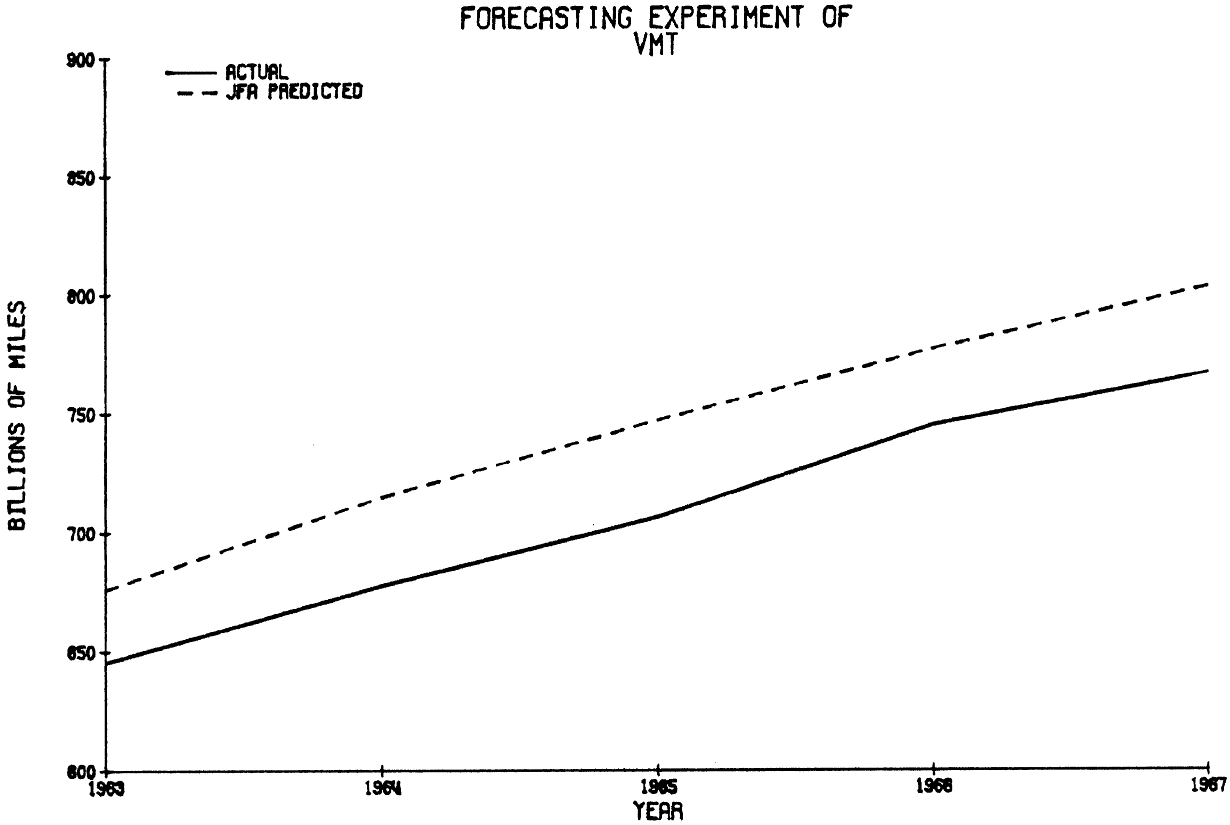


FIGURE 6-14

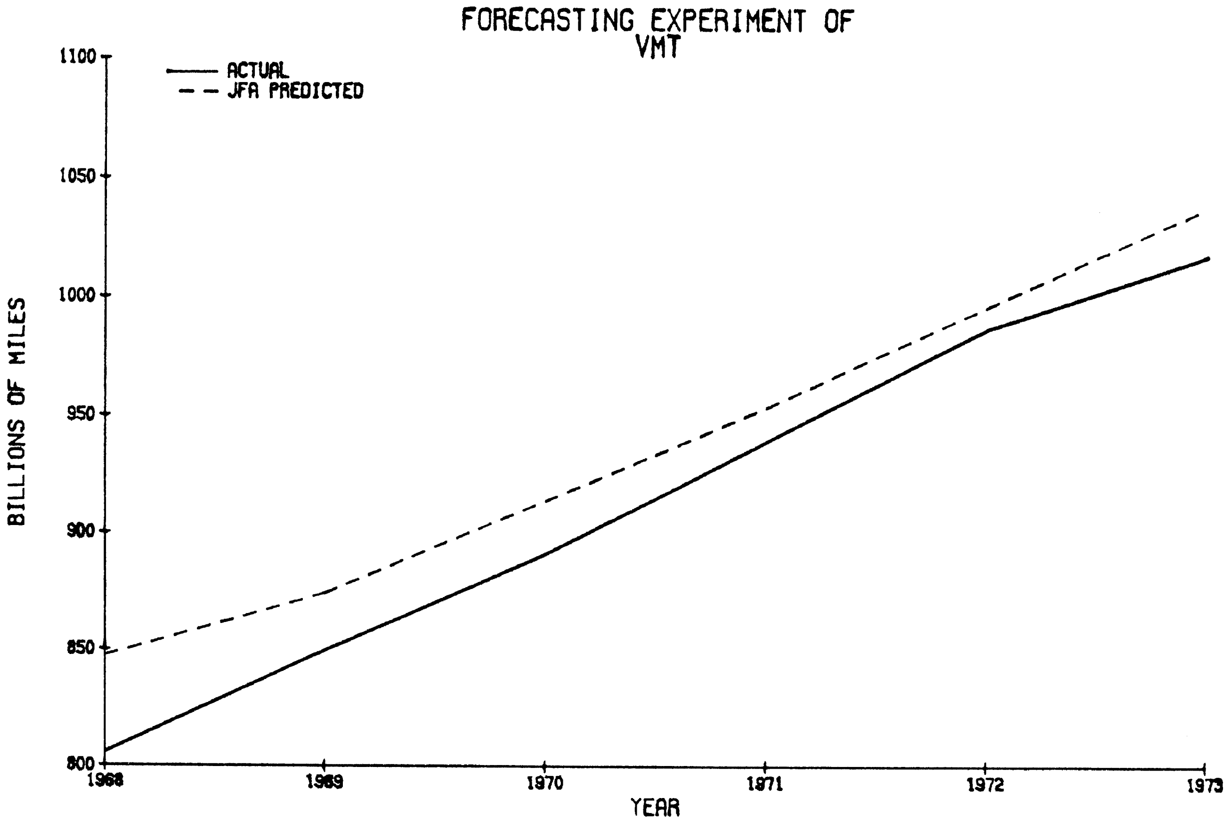


FIGURE 6-15

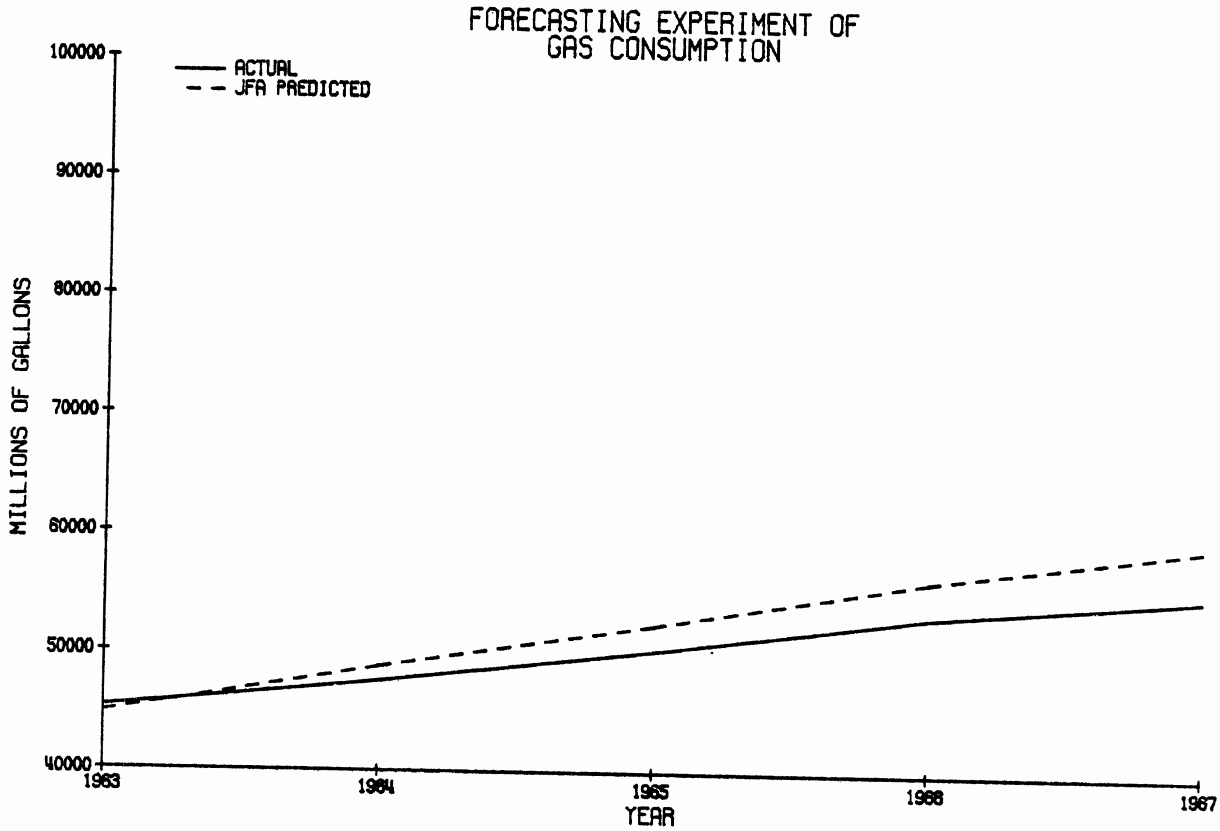


FIGURE 6-16

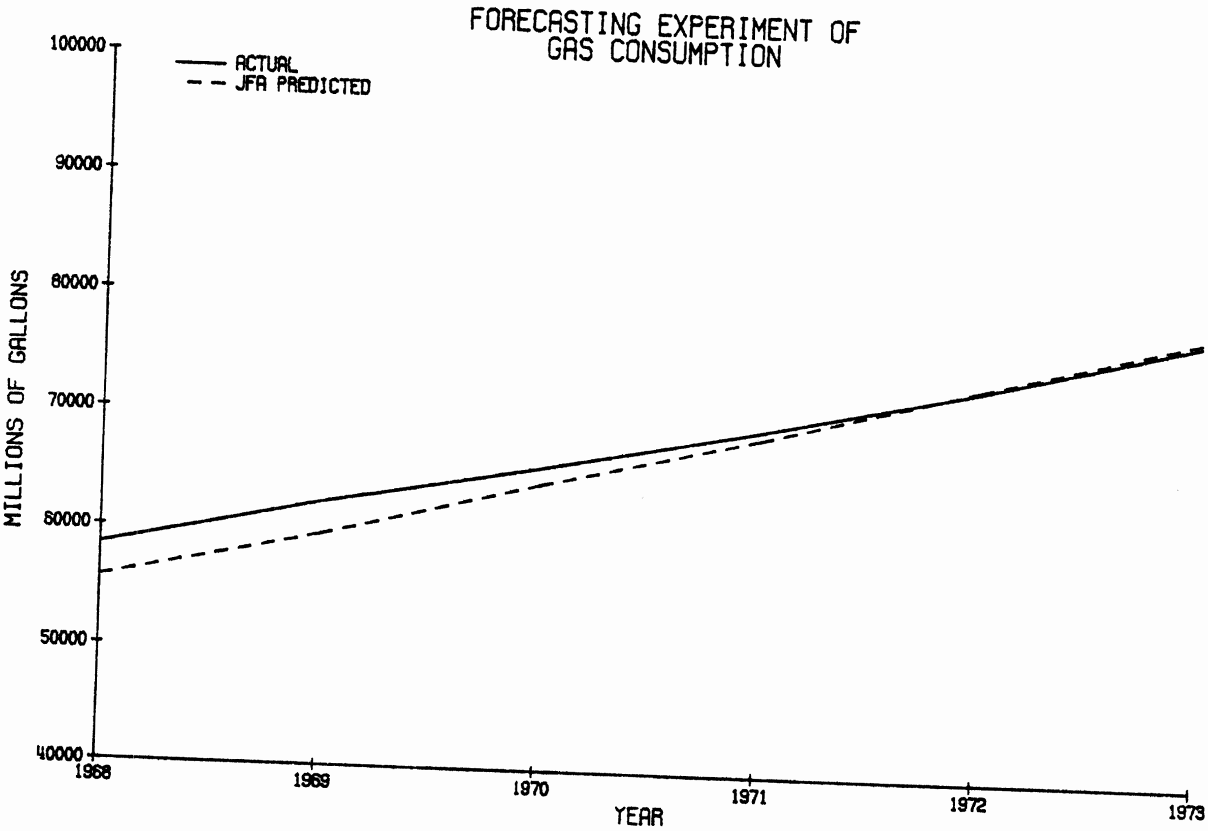


FIGURE 6-17

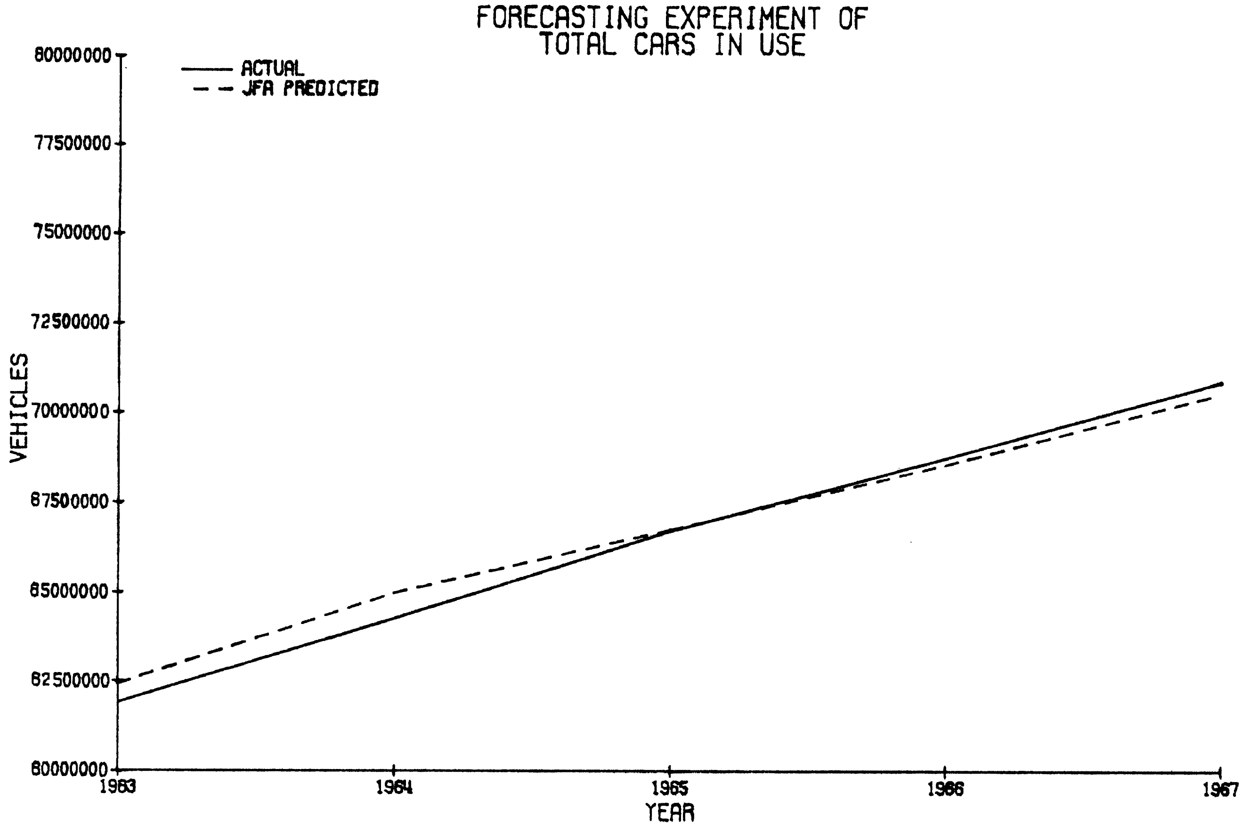


FIGURE 6-18

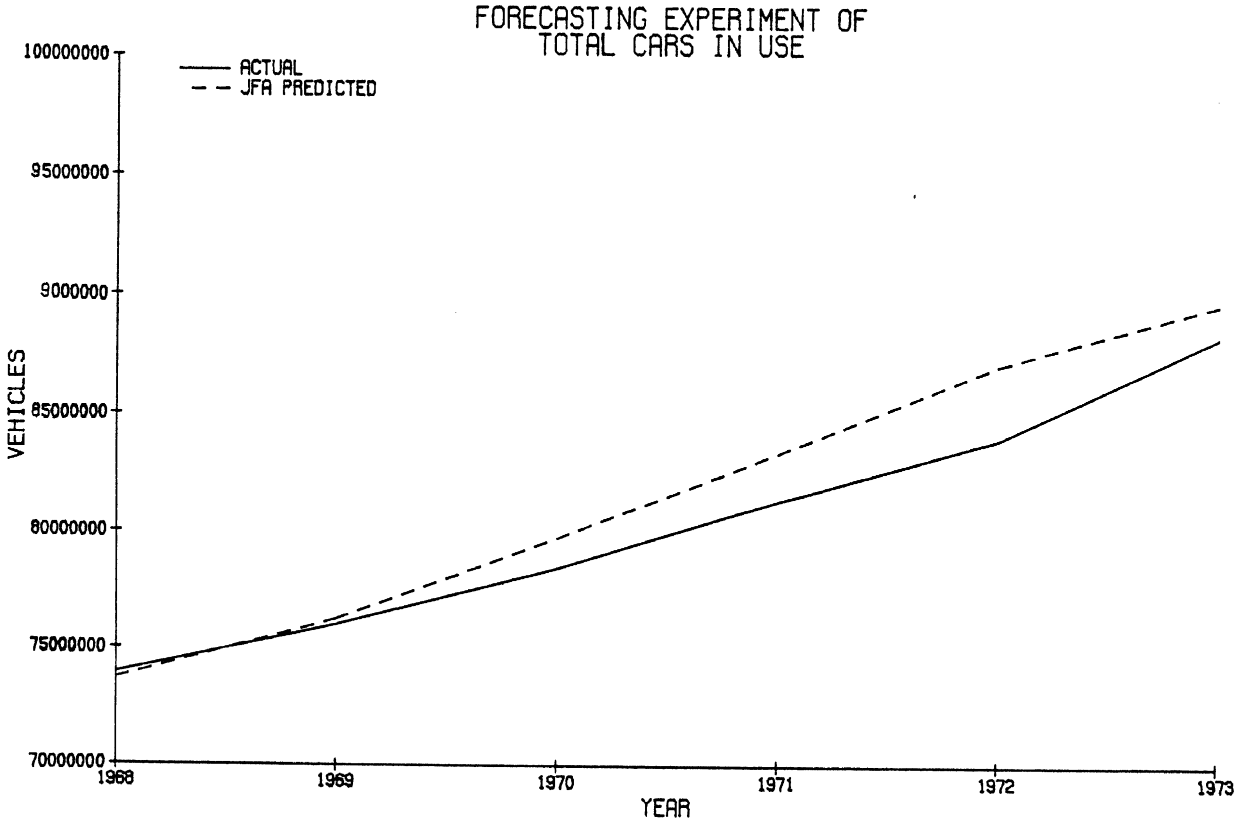


FIGURE 6-19

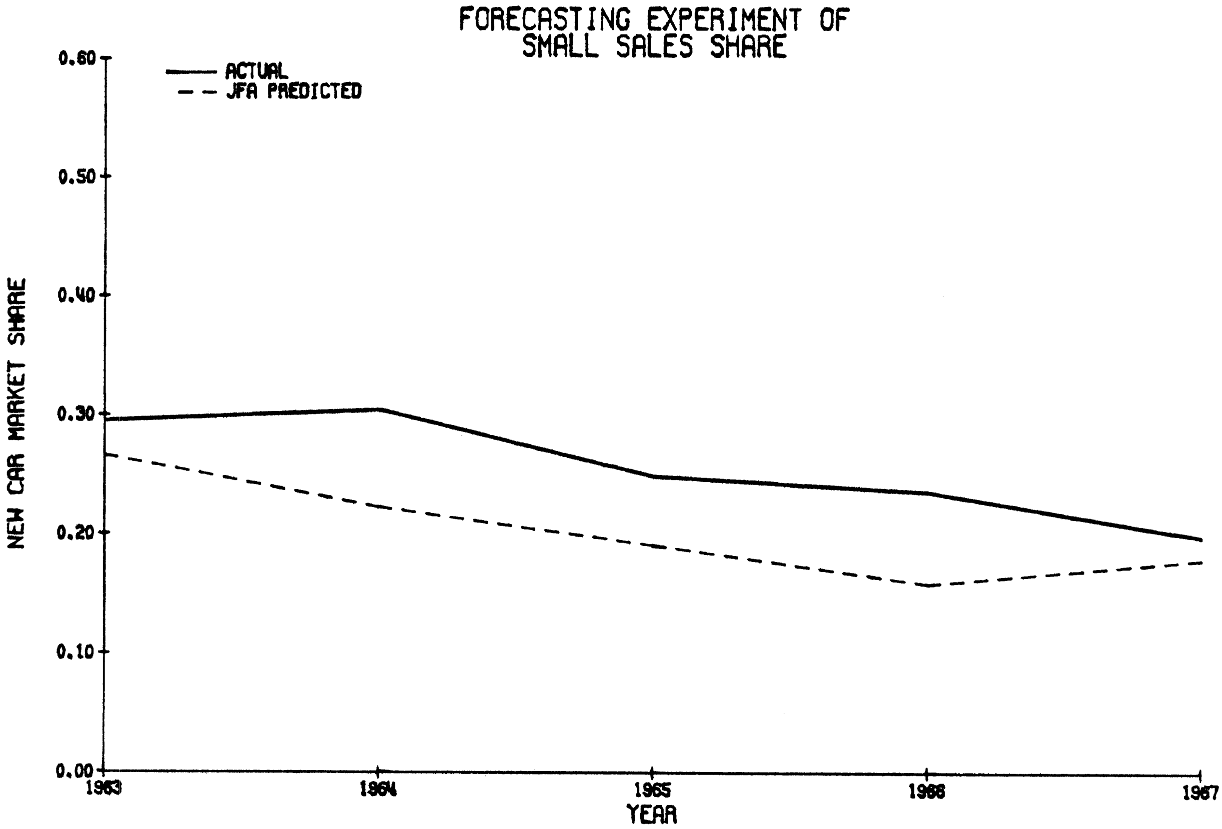


FIGURE 6-20

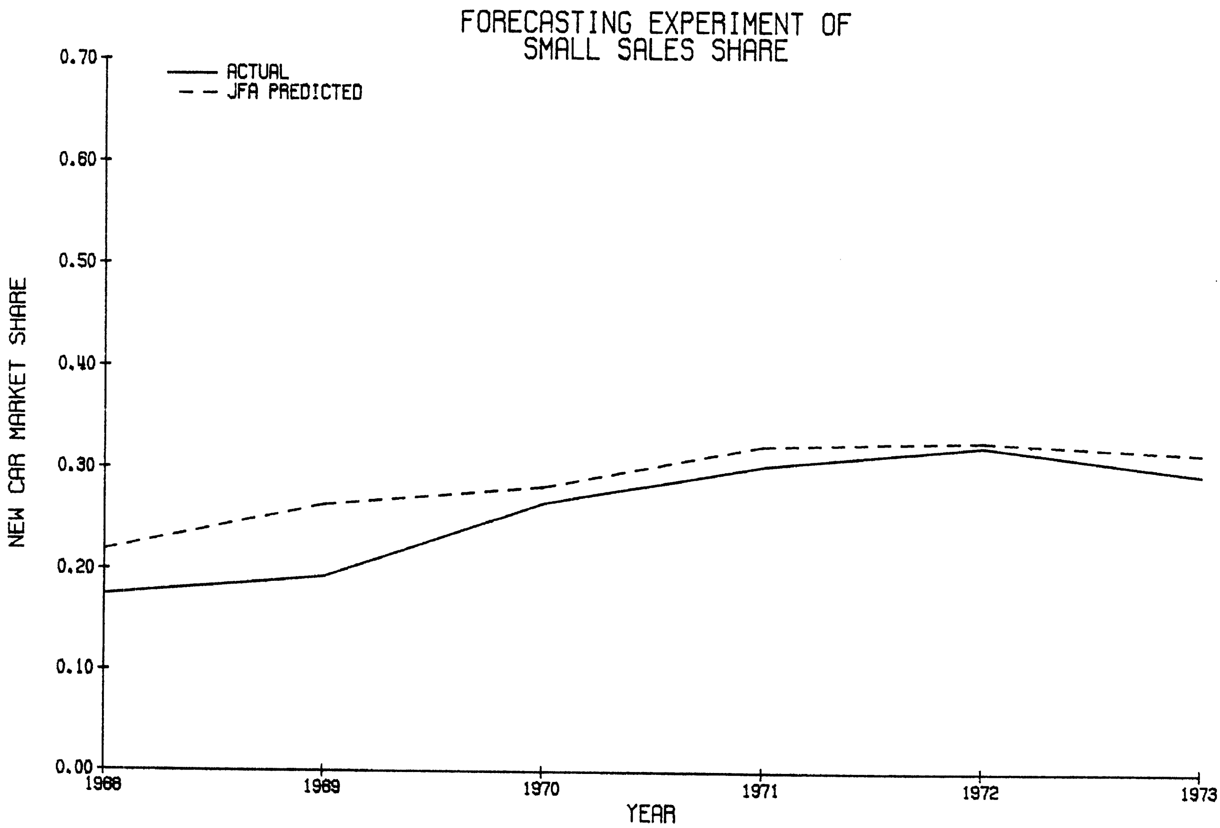


FIGURE 6-21

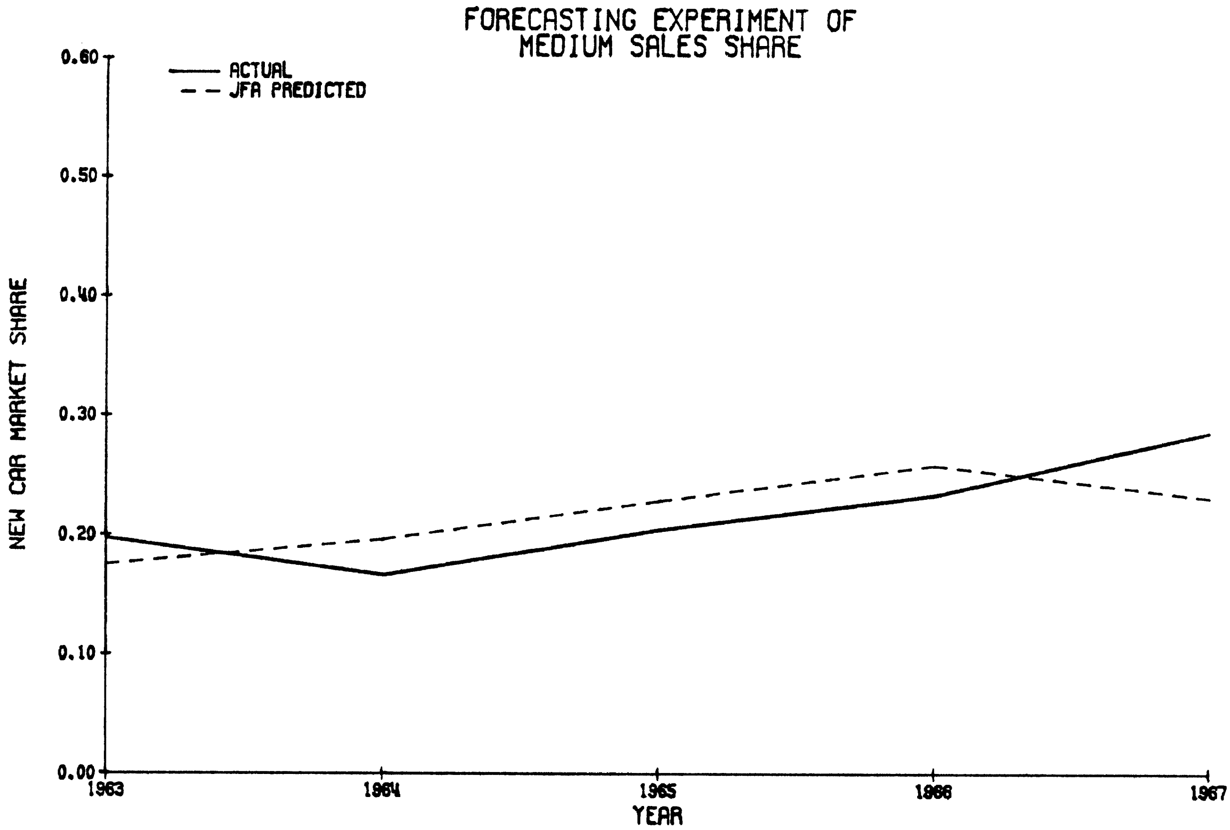


FIGURE 6-22

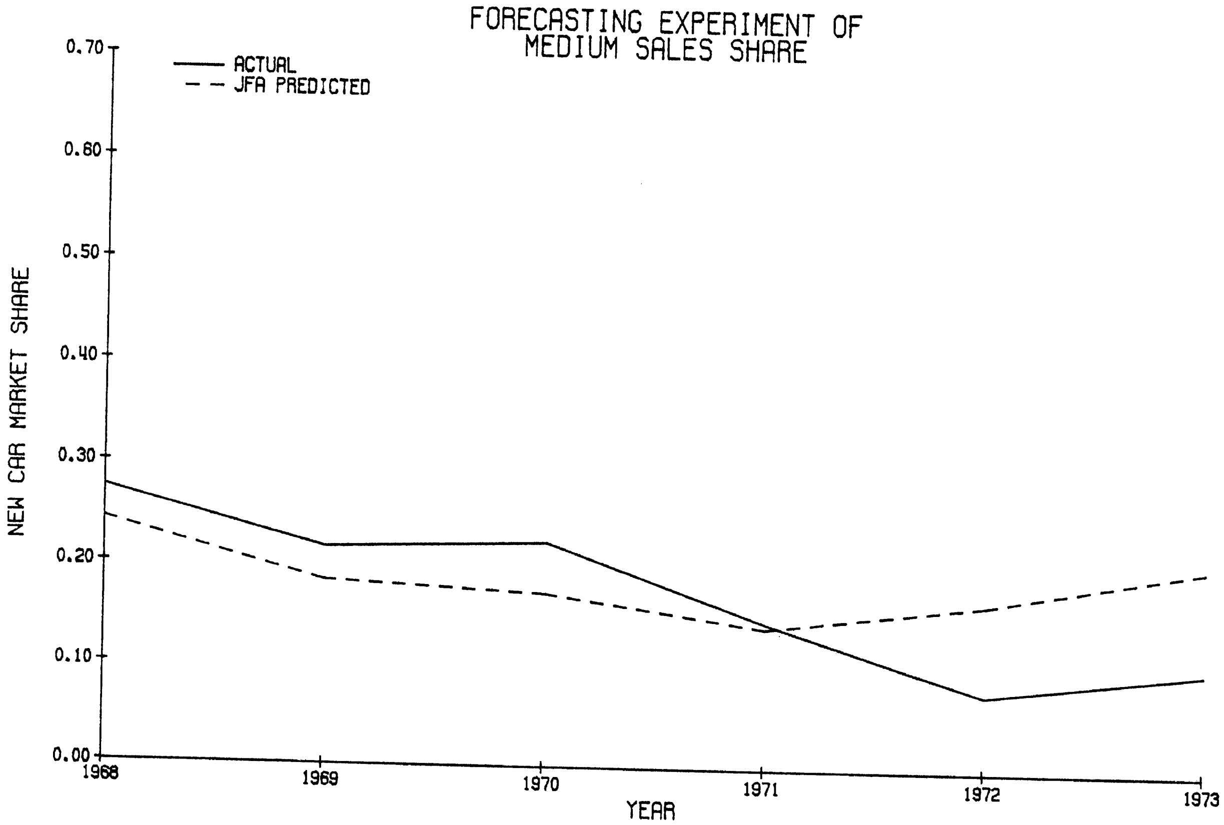


FIGURE 6-23

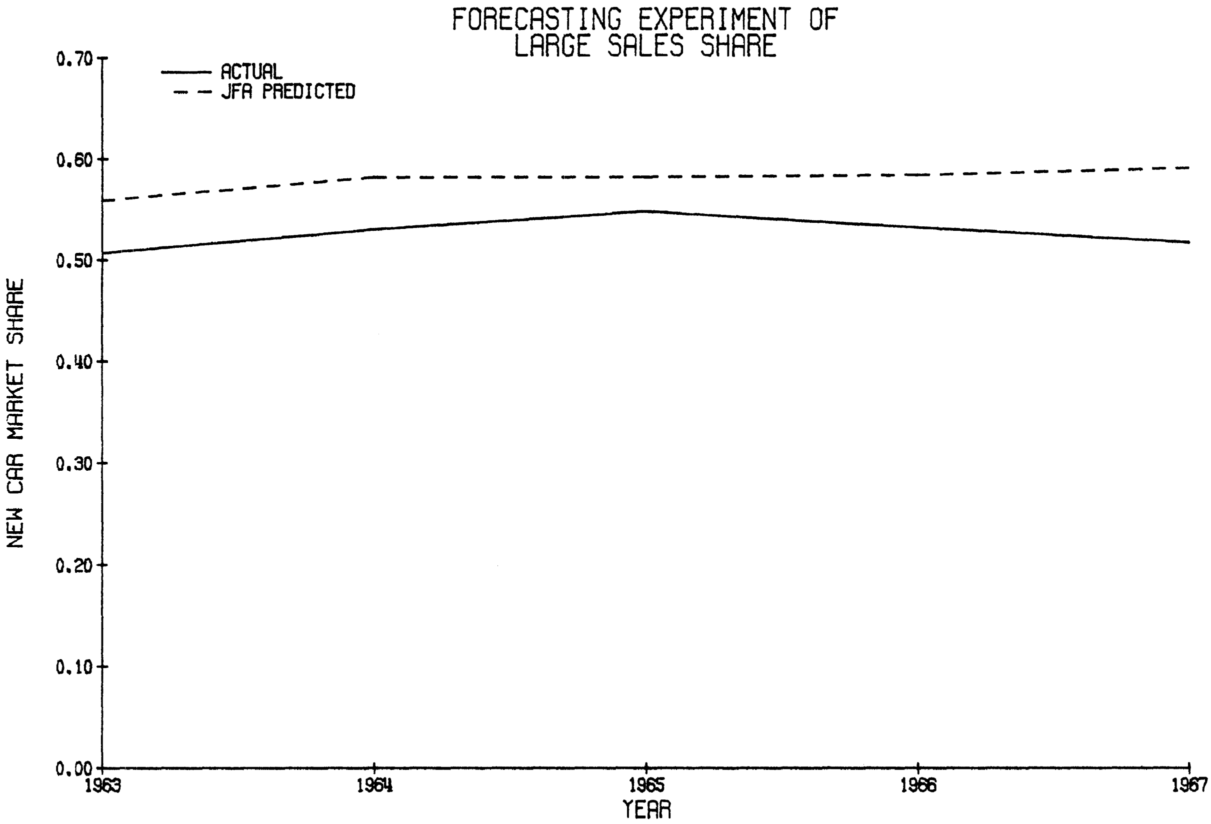
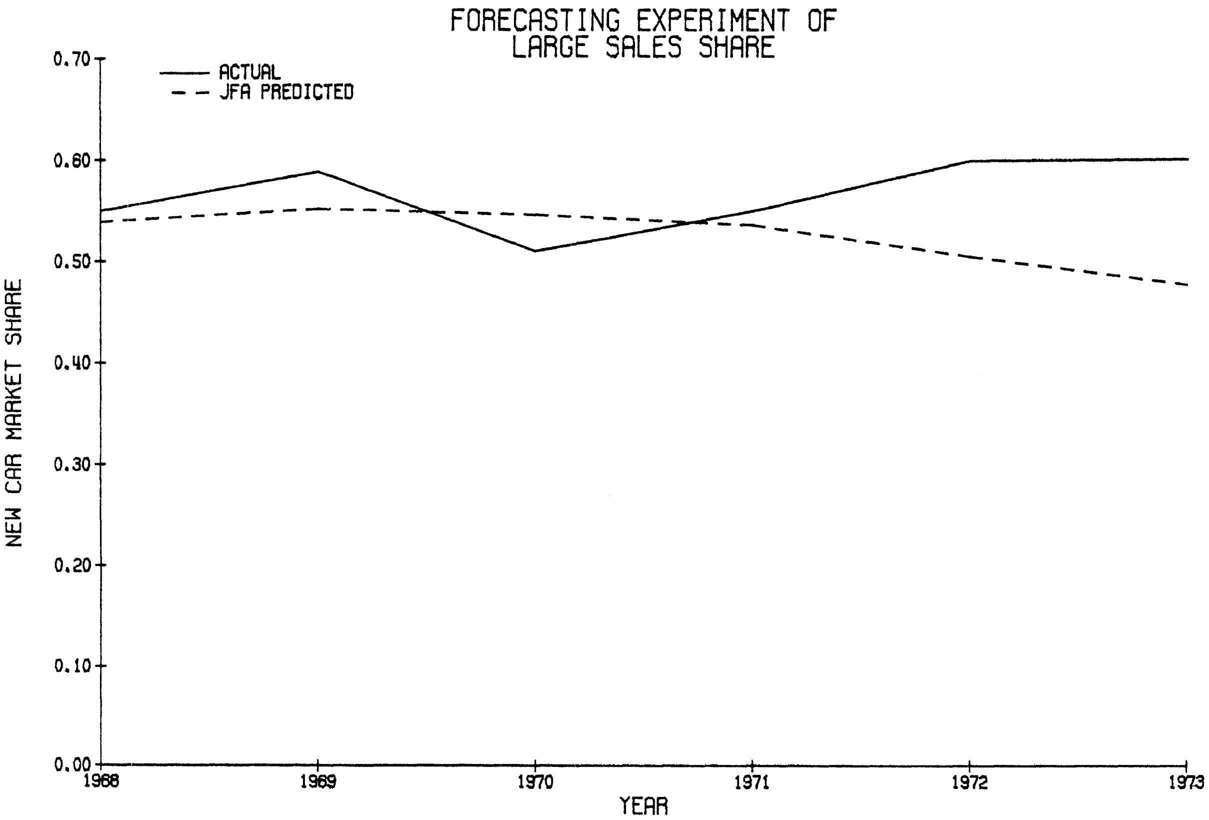


FIGURE 6-24



the first half-period is not carried over to the second. Thus, the lower %RMSE in both periods suggests that the gasoline consumption forecast accumulates error as the forecasting horizon is lengthened.

6.4 Forecasting Experiment on Error Accumulation

In this experiment four types of forecasts were made to determine if the model tends to accumulate errors as the forecasting horizon is lengthened. The four types were:

- one-period forecasts
- two-period forecasts
- four-period forecasts
- six-period forecasts

One-period forecasts are also known as static forecasts while the others (two-, four-, and six-period forecasts) are known as dynamic forecasts. In the one-period forecasts the model is reinitialized each year so that actual values of all lagged endogenous forecast variables are always used to produce one-year-ahead forecasts. One-period forecasts do not accumulate forecasting errors and thus provide a useful benchmark for comparison with the results of the dynamic experiments.

In the two-period forecast the model is reinitialized every other year. Forecasts for each year depend on forecasts for the immediately preceding year. For example, to generate the 1968 forecast the model was initialized with the actual 1966 values of all the 1966 endogenous variables. The 1966 actual values were used to forecast the 1967 values that are used to generate the 1968 forecasts. To produce the next year's forecasts, the model is reinitialized with 1967 actual values, and new 1968 forecasts are produced that are then used to generate 1969 forecasts. This procedure yields a series of two-period-ahead forecasts. A similar procedure is followed for the four- and six-year forecast horizons. For a six-period forecast the model is initialized with actual data six periods prior to the forecast period. As the necessary data were unavailable for years prior to 1962 the earliest possible six-period forecast year was 1968. To be comparable, forecasts for all four period lengths were performed over the period 1968-1973.

The results of the experiment are summarized in Table 6-6. The one-period forecasts of sales, scrappage, gasoline consumption, and market shares have higher %RMSEs. Cars in use and VMT are forecast relatively more accurately as indicated by the lower %RMSEs.

If the Demand Block tends to accumulate error, the error contained in the one-period forecasts may compound over the longer forecast horizons. Error accumulation is evidenced by rising RMSEs and falling SIML R-SQs as the forecasting horizon lengthens. Table 6-6 shows that sales, scrappage, VMT, gas consumption, and small-car market share forecasts do not tend to accumulate error. Going across the table from the one-period to six-period forecasts, there is a declining trend in the RMSEs of these five variables. Similarly the trend of the SIML R-SQs is an increasing one. Cars in use, and large- and medium-car market shares forecasts, however, demonstrate a tendency to accumulate error.

Curiously, sales, scrappage, and gasoline consumption forecasts all have falling RMSEs from the one- to the four-period forecasts, but in going to the six-period forecasts the RMSEs rise. In the case of gasoline consumption this pattern is especially striking. The gasoline consumption forecasts reveal that this RMSE pattern is produced because, as the forecast horizon is lengthened, the forecasts all become higher. For example, the 1968 one-period-ahead forecast is 55654, an underprediction of the actual, which equals 58413. The 1968 two-period-ahead forecast is 57672, the four-period-ahead, 60607. The six-period-ahead forecast rises to 63300, a substantial overprediction.

The HSRI staff performed additional experiments changing the levels and/or trends of the exogenous variables, and exogenizing several endogenous variables. Based on these experiments the HSRI staff identified only one variable--gasoline price--that affects the gasoline consumption RMSE pattern, suggesting that the relatively low gasoline prices of the historical period may underlie the increases. Gasoline prices of $1.58 ($1975) or higher, on the other hand, drive the model to lower and lower gasoline consumption as the forecasting horizon increases. This tendency of the model to trend in one direction or another is disturbing, for it suggests that the model cannot forecast turns in gasoline consumption.

TABLE 6-6

ERROR STATISTICS FOR 1968-1973 BY LENGTH OF FORECAST HORIZON

VARIABLE	MEAN ACTUAL	RMSE 1	RMSE 2	RMSE 4	RMSE 6
Sales	9,906,000	878,400	774,300	732,100	799,500
Scrappage	7,012,000	654,800	612,900	583,100	642,700
Total VMT (in billions)	914.7	23.34	24.56	22.22	19.75
Gas Consumption (in millions)	67,720	5,918	3,792	1,309	2,761
Cars in Use	80,330,000	903,600	1,294,000	1,632,000	1,658,000
Small car Market Share	.2592	.02956	.03574	.03027	.02827
Medium car Market Share	.1737	.04984	.06893	.06952	.06930
Large car Market Share	.5671	.05308	.06991	.06460	.06796

	% RMSE 1	% RMSE 2	% RMSE 4	% RMSE 6
Sales	8.867	7.816	7.390	8.071
Scrappage	9.339	8.741	8.459	9.166
Total VMT	2.551	2.685	2.429	2.159
Gas Consumption	8.738	5.600	1.933	4.078
Cars in Use	1.125	1.611	2.031	2.064
Small car Market Share	11.40	13.79	11.68	10.91
Medium car Market Share	28.70	39.69	40.03	39.90
Large car Market Share	9.359	12.33	11.39	11.98

TABLE 6-6 (continued)

ERROR STATISTICS FOR 1968-1973 BY LENGTH OF FORECAST HORIZON

VARIABLE	SIML R-SQ			
	1	2	4	6
Sales	.1508	.3401	.4101	.2964
Scrappage	.01459	.1367	.1915	.05084
Total VMT	.9006	.8899	.9099	.9288
Gas Consumption	.1575	.6540	.9588	.8165
Cars in Use	.9651	.9283	.8661	.8824
Small car Market Share	.7223	.5940	.7087	.7458
Medium car Market Share	.5025	.04841	.03227	.03835
Large car Market Share	-1.543	-3.412	-2.767	-3.169

6.5 Ex Ante Forecasting Experiment 1976-1978

One important test of a model is how well it forecasts beyond the sample period. Since the latest sample period used to estimate the Faucett model ends with 1975, it is possible to compare the model's ex ante forecasts with historical values. The HSRI staff exercised both the uncorrected and corrected versions of the model to forecast for the period 1976-1978. This forecasting experiment tests only the model's relatively short-run forecasting accuracy. Longer-run forecasts are expected to be less accurate, particularly given the tendencies of some variables to accumulate error.

Unlike the experiments of Sections 6.1 to 6.4, the ex ante forecasting experiment was performed with the full model. Another unique aspect of the ex ante forecasts is that they were performed using the model authors' predicted values of all exogenous variables (e.g., population and income projections) except fuel prices. The actual values of fuel prices were input to the model because the model authors did not provide predicted values. The prices (per gallon, in 1974 dollars) were \$.5111 for 1976, \$.5127 for 1977, and \$.4762 for 1978 (U.S. Bureau of Census 1978 and 1979).

Results of the experiment are presented in Table 6-7 for three variables: new-car sales, VMT, and gasoline consumption. Calculation of actual values for prices by class, and other variables for comparison with the forecast values is judged to be impractical, although tentative values were calculated for market shares for two years (Table 6-8). Not only are the calculations tedious, but the HSRI staff is uncertain about the exact methods of calculation used by JFA, since their methods are inadequately documented.

The uncorrected version's forecasts of new-car sales differed from the actual values by 1.38% in 1976, 3.21% in 1977, and 9.48% in 1978. VMT forecasts differed from actual VMT by 3.64%, 4.31%, and 4.33% for 1976, 1977, and 1978, respectively. Gasoline consumption forecasts differed by less than one percent from the actual values in the first two years, and by slightly more than one percent in 1978. Considering the model's shortcomings these errors are quite small. However, the seemingly high degree of forecast accuracy for new-car sales, and to a lesser extent for gasoline consumption, can be specifically attributed to two questionable procedures.

First, the model's new-car sales forecasts are changed to equal the new-car sales forecasts of a Data Resources Incorporated (DRI) model. (See Section 5.7 for a discussion of the DRI factor.) The Faucett model is programmed so that this change has no effect on the forecasts of the other endogenous variables. The model's sales forecasts are simply modified by a DRI factor, so that eliminating this factor reveals the new-car sales forecasts actually generated by the model. These forecasts differ from actual new-car sales by 46.9%, 20.01%, and 20.30% in 1976, 1977, and 1978, respectively. The DRI factor equals 0.69 in 1976, 0.86 in 1977, and 0.91 in 1978. The DRI factors for 1979-1984 are: 0.95, 0.97, 1.01, 1.03, 1.02, and 1.02. After 1984 the DRI factor is 1.03. Obviously, the DRI factor is most important for the early years, particularly 1976 and 1977.

Second, end-of-the-year auto stock is used in the VMT equation when forecasting, while beginning-of-the-year stock was used to estimate the VMT equation. As end-of-the-year stock exceeds beginning-of-the-year stock, VMT is overestimated. Higher forecasts of VMT result in higher forecasts of gasoline consumption. The HSRI corrected version of the model eliminates this error. Comparison of the results of the corrected and uncorrected versions in Table 6-7 shows that the forecasts of VMT improve, while the forecasts of gasoline consumption are less accurate, once this error is eliminated.

While the second procedure appears to be a simple error, the first procedure has no apparent justification other than to seemingly improve the short-term forecasting accuracy of the model. That these procedures will improve the model's long-run forecasting accuracy is doubtful.

Removing the DRI factor unmasks the extremely poor accuracy of the new-car sales forecasts generated by the model. To improve this forecast the HSRI staff's corrected version of the model was modified to replace

TABLE 6-7

EX ANTE FORECASTS
JFA VERSION

VARIABLE	ACTUAL*	FORECAST	DIFFERENCE
	1976		
Sales	9859726	9996053	-136327
Sales Without DRI	9859726	14487033	-4627307
VMT	1075.76	1114.923	-39.163
Gas Consumption	78398.31	78626.625	-228.315
	1977		
Sales	10946405	11297456	-351051
Sales Without DRI	10946405	13136577	-2190172
VMT	1118.65	1166.848	-48.198
Gas Consumption	80225.46	80492.313	-266.853
	1978		
Sales	11067606	12116743	-1049137
Sales Without DRI	11067606	13314758	-2247152
VMT	1171.092	1221.769	-50.677
Gas Consumption	83311.868	82351.938	959.93

VARIABLE	RMSE
Sales	643560
Sales Without DRI	3227878
VMT	46.28
Gas Consumption	590.14

*Sources:

Sales are from Automotive News Market Data Book 1979, New Car Registrations by makes 1970-78. This series was adjusted upward by 1.0111% to reflect differences from the data used to estimate the model, which are from Automotive News Almanac 1975, Auto Scrappage Since 1925.

VMT and gas consumption are from FHWA's Highway Statistics, Annual, and data supplied in advance of publication by the FHWA Highway Statistics Division.

TABLE 6-7 CONTINUED

EX ANTE FORECASTS
HSRI CORRECTED VERSION

VARIABLE	ACTUAL	FORECAST	DIFFERENCE
		1976	
VMT	1075.76	1074.344	1.416
Gas Consumption	78398.31	75765.063	2633.247
		1977	
VMT	1118.65	1139.704	-21.054
Gas Consumption	80225.46	78619.875	1605.585
		1978	
VMT	1171.092	1197.867	-26.775
Gas Consumption	83311.868	80740.938	2570.93

VARIABLE	RMSE
VMT	19.68
Gas Consumption	2318.16

TABLE 6-7 CONTINUED

EX ANTE FORECASTS
HSRI CORRECTED AND VARIABLE AVERAGE GENERALIZED PRICE

1976	ACTUAL	FORECAST	DIFFERENCE
	1976		
Sales	9859726	8019883	1839843
Sales Without DRI	9859726	11623018.84	-1763293
VMT	1075.76	1074.077	1.683
Gas Consumption	78398.31	76174.250	2224.06
	1977		
Sales	10946405	10230208	716197
Sales Without DRI	10946405	11895590.7	949185
VMT	1118.65	1121.149	-2.499
Gas Consumption	80225.46	77913.563	-2311.897
	1978		
Sales	11067606	11151282	-83676
Sales Without DRI	11067606	12254156	-1186550
VMT	1171.092	1171.395	-.303
Gas Consumption	83311.868	79593.500	3718.368

VARIABLE	RMSE
Sales	1140901
Sales Without DRI	1343882
VMT	1.75
Gas Consumption	2835.35

the constant Average Generalized Price ($A_t = A_{1975}$) used in the market shares equation with A_t calculated using lagged market shares. As shown in Table 6-7, allowing A_t to vary improves the new-car sales forecasts dramatically without sacrificing the accuracy of the VMT and gasoline forecasts.

To check the accuracy of the market shares forecasts, the HSRI staff calculated tentative market shares for 1976 and 1977 following, to the extent possible, JFA's method. From Table 6-8 one can see that neither version forecasts market shares without percentage errors in the 50 to 100 percent range. The JFA version forecasts the small-car share somewhat more accurately, and the other two shares less accurately. However, the differences between the two sets of market shares forecasts are always less than 8%.

The ex ante forecasts discussed above depend on the price of leaded regular gasoline, which was used in estimating the model. In the postsample period, however, an increasing proportion of consumption has been, and is likely to continue to be, higher priced unleaded gasoline. The HSRI staff calculated consumption-weighted averages of leaded and unleaded gasoline prices for 1976-1978 (\$.5176, \$.5203, \$.4900) (Source: U.S. Monthly Energy Review, August 1979). Ex ante forecasts of sales, VMT, and gasoline consumption based on these prices are presented in Table 6-9 for comparison with the forecasts in Table 6-7. The forecasts based on the weighted average prices have lower RMSEs for sales and VMT, but a higher RMSE for gasoline consumption despite producing more accurate forecasts for two of the three years.

The gasoline price data can be used to illustrate an important point about the computational (not statistical) accuracy of the model's forecasts (16). The model authors apparently used four-digit (e.g., .4172) gasoline prices for estimation purposes. The HSRI staff copied this procedure in the forecasting experiments. Examination of the model author's data source revealed that the gasoline prices were originally two-digit approximations (e.g., .63) in current dollars. The four digits result from the conversion to constant 1974 dollars, and the last two digits are not computationally significant. It follows that, despite the accurate-looking

TABLE 6-8

COMPARISON OF MARKET SHARES FORECASTS BY JFA VERSION AND HSRI CORRECTED VERSION WITH A_t VARIABLE

	1976				1977			
	Actual	Forecast	DIFF	%DIFF	Actual	Forecast	DIFF	%DIFF
JFA VERSION								
SMALL	26.5%	22.0%	5.4%	17.0%	27.6%	19.8%	7.8%	28.2%
MEDIUM	17.4%	29.4%	-12.0%	69.1%	15.3%	32.1%	-16.8%	-110.0%
LARGE	56.1%	48.6%	7.5%	13.3%	57.1%	48.1%	9.0%	15.8%
HSRI CORRECTED W/ A_t VARIABLE								
SMALL	26.5%	20.5%	6.0%	22.8%	27.6%	18.1%	9.5%	34.5%
MEDIUM	17.4%	28.1%	-10.7%	61.5%	15.3%	29.9%	-14.6%	95.5%
LARGE	56.1%	51.4%	4.7%	8.3%	57.1%	52.0%	5.1%	8.9%

To validate the HSRI staff's attempt to follow JFA's procedure in calculating actual market shares, the HSRI staff calculated shares for 1973, the last year for which actual shares are given by JFA. The results are presented below:

	SMALL	MEDIUM	LARGE
ACTUAL 1973 AS CALCULATED BY JFA	29.6%	10.2%	60.2%
ACTUAL 1973 AS CALCULATED BY HSRI	32.6%	10.1%	57.3%
DIFF	-3.0%	0.1%	2.9%
%DIFF	10.1%	<1%	4.8%

TABLE 6-9

EX ANTE FORECASTS
USING WEIGHTED AVERAGE OF LEADED AND UNLEADED GASOLINE PRICES

VARIABLE	ACTUAL	FORECAST	DIFFERENCE
1976			
Sales	9859726	9931282	-71556
Sales Without DRI	9859726	14132587	-4272861
VMT	1075.76	1113.462	-37.702
Gas Consumption	78398.31	78537.563	-139.253
1977			
Sales	10946405	11241151	-294746
Sales Without DRI	10946405	13071106	-2124701
VMT	1118.65	1164.808	-46.158
Gas Consumption	80225.46	80373.813	-148.353
1978			
Sales	11067606	12007217	-939611
Sales Without DRI	11067606	13194743.96	-2127138
VMT	1171.092	1218.008	-46.916
Gas Consumption	83311.868	82088.188	1223.68

VARIABLE	RMSE
Sales	570048
Sales Without DRI	3016411
VMT	43.79
Gas Consumption	716.19

three-decimal-place forecasts produced by the model, the number of meaningful digits in the forecasts is limited by the two digits in the gasoline price data. To examine the number of meaningful digits in the forecasts, two alternative sets of ex ante forecasts were produced using gasoline prices one-half cent above and below the prices reported in the original data source ($\pm$\$.005 represents the limits of potential rounding error). The resulting forecasts form a band of computational accuracy for each variable, and are presented in Table 6-10. The forecasts of sales differ in the ten thousands column, of gasoline consumption differ in the millions column, and of VMT differ in the hundred millions column, indicating that these digits are not significant even prior to consideration of statistical significance. The HSRI staff did not examine all of the other data used as inputs to the model, but it is conceivable that a limited number of significant digits in other data may further reduce the number of significant (meaningful) digits in the model's forecasts.

6.6 Comparison of the Faucett Model to a Time Trend

The objective of this section is to compare the forecasting ability of the Faucett model to a standard benchmark. One benchmark is a naive time trend extrapolation. Using this technique one can assess the relative ability of the Faucett model to predict economic results for the sample period over which it was estimated. Since the time trend is a purely mechanical technique that does not incorporate economic analysis, it is an appropriate standard of comparison. One would expect model builders to be able to develop models whose performance is superior to a simple trend extrapolation. One reason for this is that model builders can always adopt the time trend as their model and then improve on that via an understanding of economics. (Of course, the inclusion of a trend variable has its own difficulties.) In any event, this comparison can yield information on how well the model performed when the existing economic conditions and values of the exogenous variables were known. Since these influences change over time, the forecasting ability of both models should decrease over time. One would expect the time trend to have relatively less continuity since many factors may cause trends to change. Because

TABLE 6-10

COMPUTATIONAL BAND ON EX ANTE JFA FORECASTS RESULTING FROM GAS PRICE (LEADED) ROUNDING ERROR

YEAR	-$.005	+$.005	DIFFERENCE
		Sales	
1976	10039312.000	9953093.000	86219
1977	11324784.000	11271093.000	53691
1978	12133484.000	12100125.000	33359
		VMT	
1976	1115.901	1113.955	1.946
1977	1168.009	1165.714	2.295
1978	1223.005	1220.525	2.480
		Gas Consumption	
1976	78686.375	78567.563	118.812
1977	80559.313	80426.875	132.438
1978	82423.875	82250.000	173.875

the econometric model is more elaborate, one would expect it to account for more changes in the economic system than the simple extrapolation. However, one would still expect the Faucett model to generate larger forecasting errors, on average, in future periods than in the sample period. Certainly, one might find that a model has a tighter fit for some specific forecast period than for its estimation period. Such an event could be attributable to the stochastic nature of the forecast rather than being a systematic result. One exception, however, is that a model could have been constructed to account for the future economic conditions (either explicitly or implicitly), and thus it would fit well for the "future" and not for the past. In this case one cannot use these data as verification of the model since these data were used to generate the model. A final comparison is the forecasting abilities of the Faucett model and the time trend. The sections that follow discuss the use of mean square error in measuring the performance of the Faucett model and the benchmark, discuss some of the history of such comparisons, explain the rationale and methods used in the HSRI staff's comparisons, and finally discuss the results.

6.6.1 Mean Squared Error and Linear Time Trend Benchmarks. In previous sections RMSE was used to describe the predictive accuracy of the Faucett model. Here the square of that statistic, mean square error (MSE), is used. This is analogous to the customary practice of describing the variability of a data set by the standard deviation and using variance hypotheses tests. However, MSE comparisons between econometric models are only descriptive measures of their relative predictive powers. Unfortunately, classical hypotheses tests cannot be used because the small sample properties of the mean square error statistic are generally not known. This problem is generally understood by econometricians and work is being done in this area (Fair 1978, forthcoming). This work is new and complex, and the statistical procedures suggested in these papers should be considered as experimental at this time. In the absence of exact hypotheses-testing techniques, mean square error statistics are almost universally presented and discussed. After acknowledging the descriptive nature of MSE comparisons, Howrey, Klein and McCarthy (1974) suggest three types of comparisons using MSE. First, comparisons within the estimation period can be made to determine which model achieves a better fit to the data. Second, the postsample MSE can be compared to the within-sample MSE to determine the temporal stability of each model. Third, the postsample MSEs for the models can be compared to determine which model had the smaller forecast error. The comparisons in this section generally follow this outline and should also be considered as descriptive of the exact hypotheses tests that would be performed in the absence of the issues raised.

These model comparisons use naive time trends as benchmarks. The time trends are simply ordinary least squares regressions of the variable in question and the calendar year called t. This benchmark is the most basic linear trend extrapolation. All the benchmarks can be written in equation form as:

$$\hat{Y}_t = \hat{a} + \hat{b}(t)$$

where the parameters a and b are estimated statistically and $\hat{Y}$ computed for year t. This benchmark is not based on economic analysis. However, it does have a numerical interpretation, which is that the benchmark should perform well when year to year changes are constant. The trend line can be written as:

$$Y_{t+1} - Y_t = Y_t - Y_{t-1} = b$$

which simply says that next year's value (Y_{t+1}) will always be this year's value (Y_t) plus the constant value b. Of course there is no obvious economic rationale for this to be true for any one variable over time and it is less compelling that such a relation should be true for all endogenous variables in a model.

Other comparative benchmarks are possible. They would typically involve one or more mechanical time series techniques. These alternative techniques would be either autoregressive or moving-average computations. When these techniques are employed, it is assumed that the future value of a variable is solely determined by its previous values and no other influences. Because of this assumption, benchmarks like these are referred to as naive forecasting techniques. The time trend extrapolation is the most naive of these naive forecasting methods. One would expect the other more sophisticated benchmarks to have substantially better forecasting performance.

Since naive extrapolations do not utilize economic analysis, one might expect any econometric model to outperform extrapolations in terms of forecasting ability. However, in the early 1950s it was recognized that some major econometric models did not outperform naive extrapolations (Christ 1956, pp. 385-408). As econometric modeling techniques developed, forecasting performance improved. By the late 1960s and early 1970s most annual econometric forecasts of GNP and its components were more accurate than simple time trends (Zarnowitz 1967; Moore 1969). Work in the area of forecast accuracy continues to be on the forefront of econometric research and has led to a growing interest in the techniques of assessing the relative performance of econometric models (Elliot and Baier 1979; Fair 1979).

6.6.2 Within-Sample Comparison of the Faucett Model and the Benchmark. In the comparison of the Faucett model with a naive time trend the first step was to estimate the time trend for each of the following endogenous variables: auto sales, scrappage, VMT, gasoline consumption, cars in use, small-car market share, medium-car market share, and large-car market share. The equations are presented in Table 6-11. The graphs of the actual values, the values generated by the Faucett model, and the time trend are presented in Figures 6-25 through 6-32. From these graphs it can be seen that some of the variables closely followed trend lines in the sample period, while others did not. One measure of the accuracy of the time trend model is MSE. That same statistic was also computed for the Faucett model. As can be seen from the first two columns of Table 6-12, the Faucett model has larger MSEs for all variables except small-car market share. Comparing MSEs it appears that a naive time trend outperformed the Faucett model. However, it would be desirable to statistically test this hypothesis. One

TABLE 6-11

TIME TREND EQUATIONS

(Standard errors in parentheses)

Variable	Sample Period*	Constant	Coefficient of t (year)	$\bar{R}^2$	SER	DF	F
New Car Sales	1963-1973	-5.5947×10^8	288980	.66418	664920	9	20.778
		(1.2477×10^8)	(63397)				
Scrappage	1963-1973	-3.6051×10^8	186530	.76635	546670	9	12.807
		(1.0258×10^8)	(52123)				
VMT	1963-1975	-66862	34.389	.97741	20.342	11	520.15
		(2968.9)	(1.5078)				
Gas Consumption	1963-1975	-5570100	2860.5	.96762	2035.0	11	359.58
		(297020)	(150.85)				
Cars in Use	1963-1973	-6134500	3147.0	.9888	1106.2	9	890.18
		(207530)	(105.48)				
Small Car Market Share	1963-1973	-5.1025	.0027236	-.07727	.053724	9	.28272
		(10.081)	(.0051224)				
Medium Car Market Share	1963-1973	19.714	-.0099191	.16654	.060081	9	2.9983
		(11.274)	(.0057285)				
Large Car Market Share	1963-1973	-13.612	.0071955	.41589	.026484	9	8.1200
		(4.9694)	(.0025251)				

*The HSRI staff chose 1963-1973 as the sample period for most of the time trends because this is the longest continuous period used in estimating the JFA model (although 1968 is omitted from the scrappage equation's sample period, its omission is not significant.) The sample period used by JFA to estimate the VMT equation included 1974 and 1975. The HSRI staff followed suit in estimating a time trend for VMT and for gasoline consumption, which in the JFA model is calculated using estimated VMT.

FIGURE 6-25

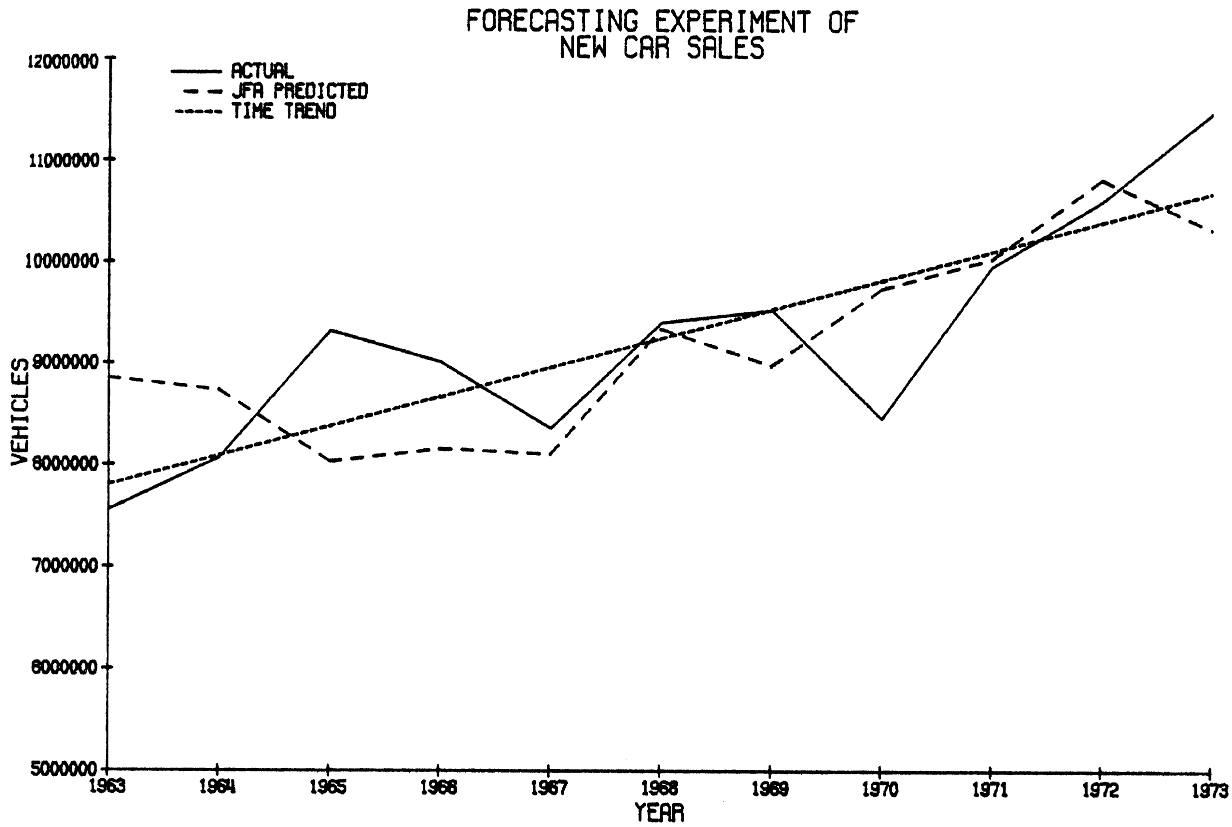


FIGURE 6-26

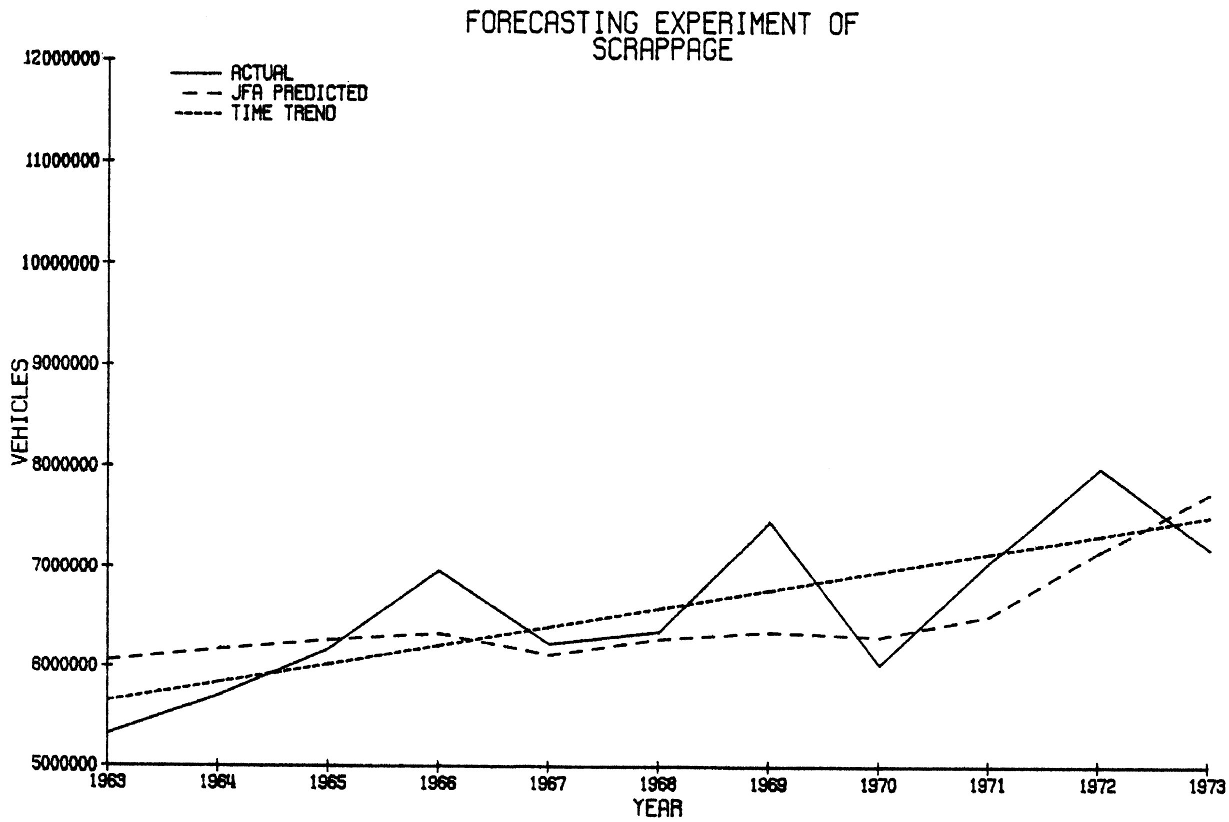


FIGURE 6-27

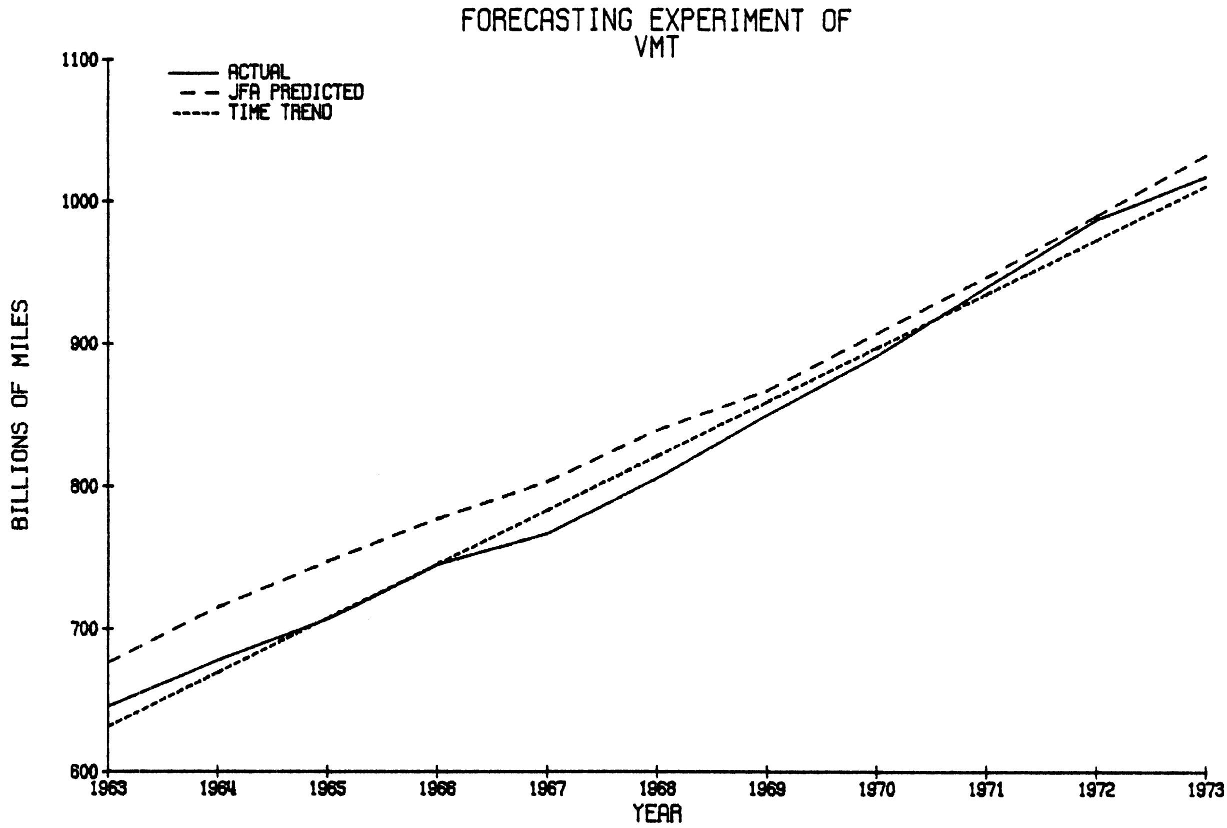


FIGURE 6-28

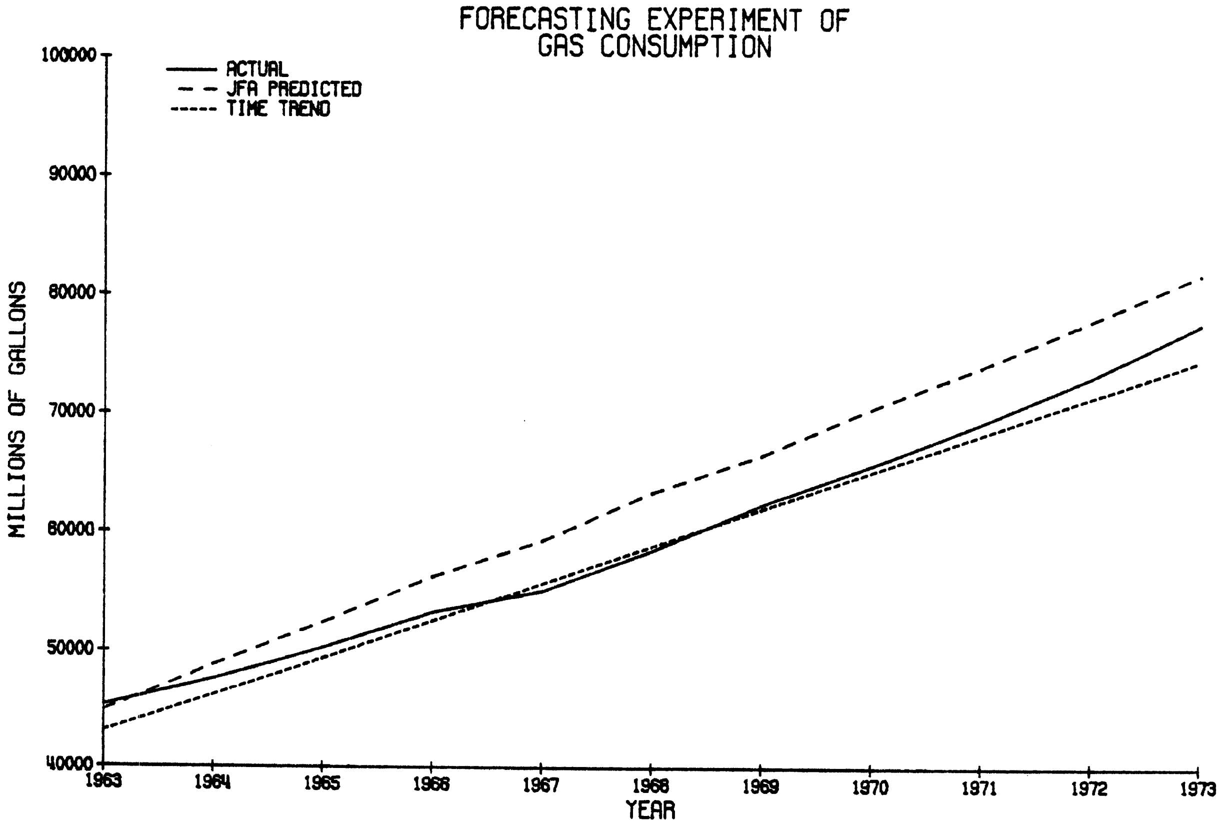


FIGURE 6-29

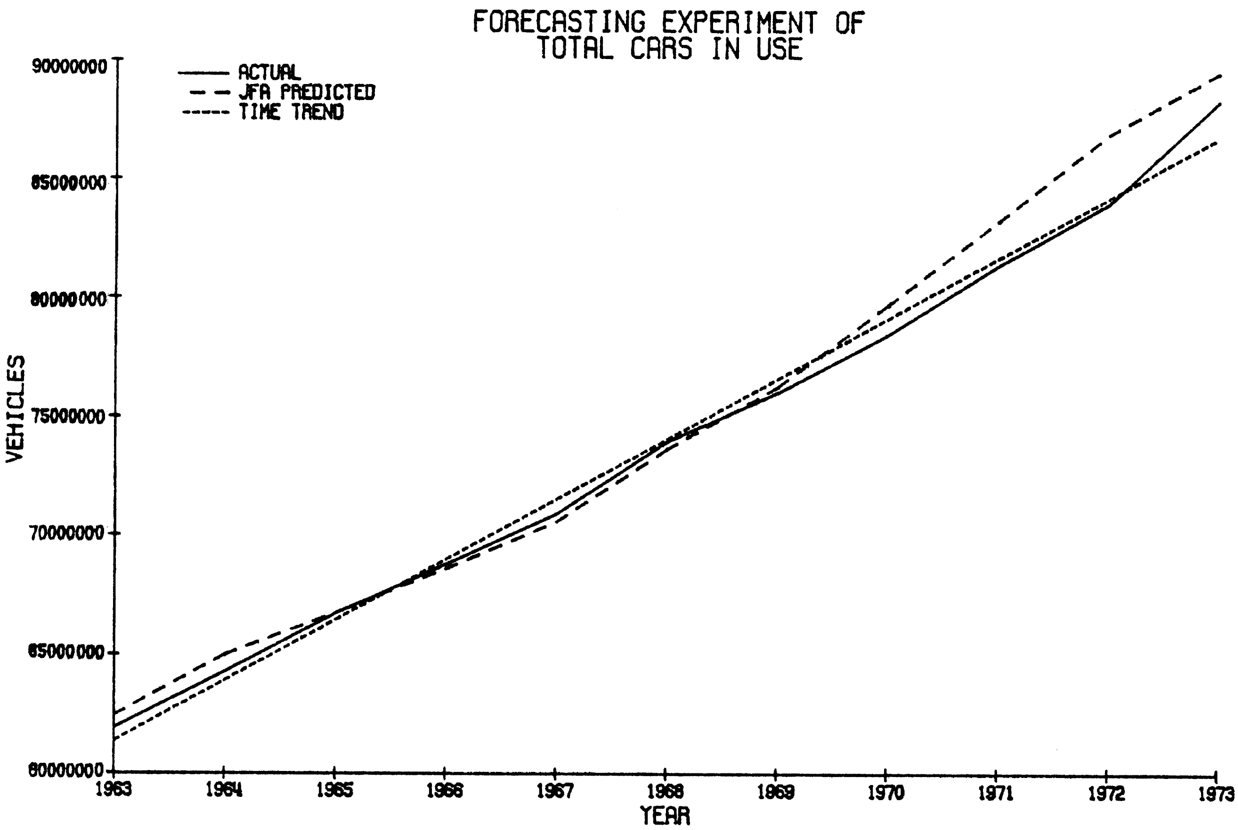


FIGURE 6-30

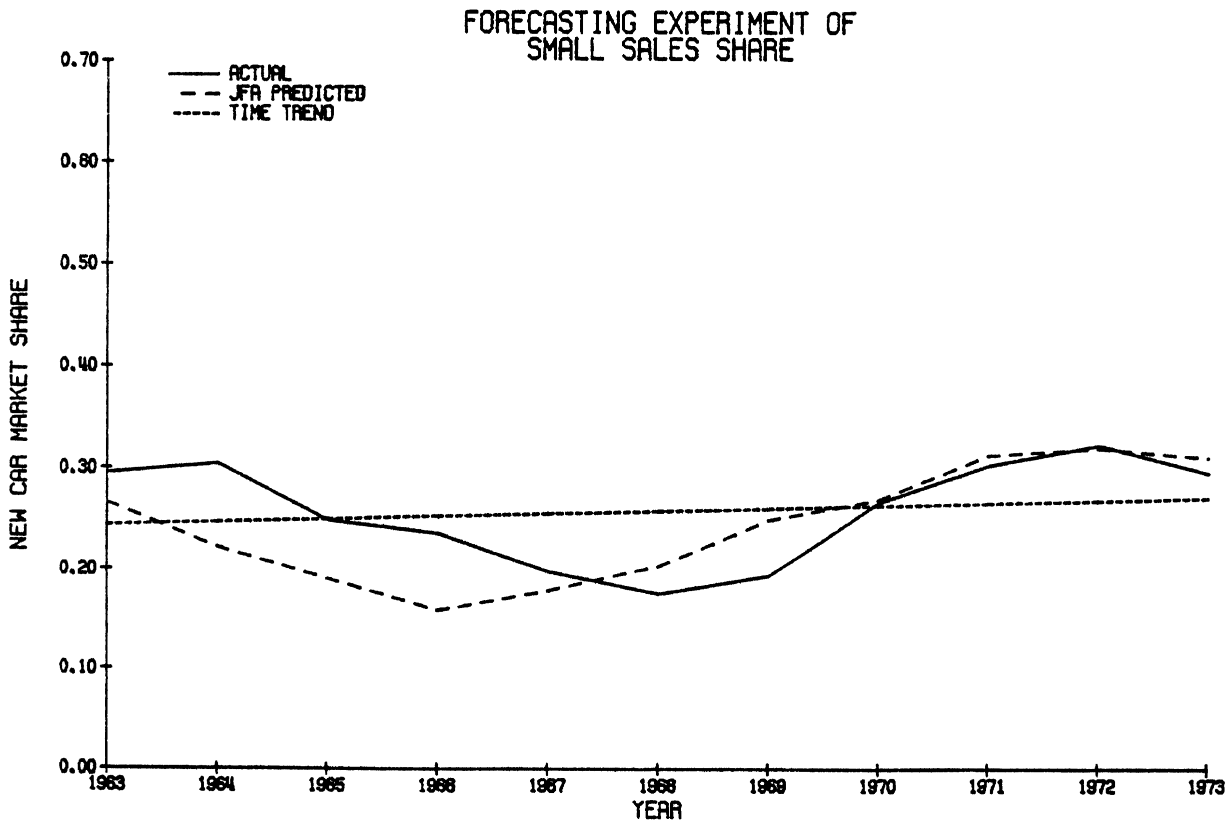


FIGURE 6-31

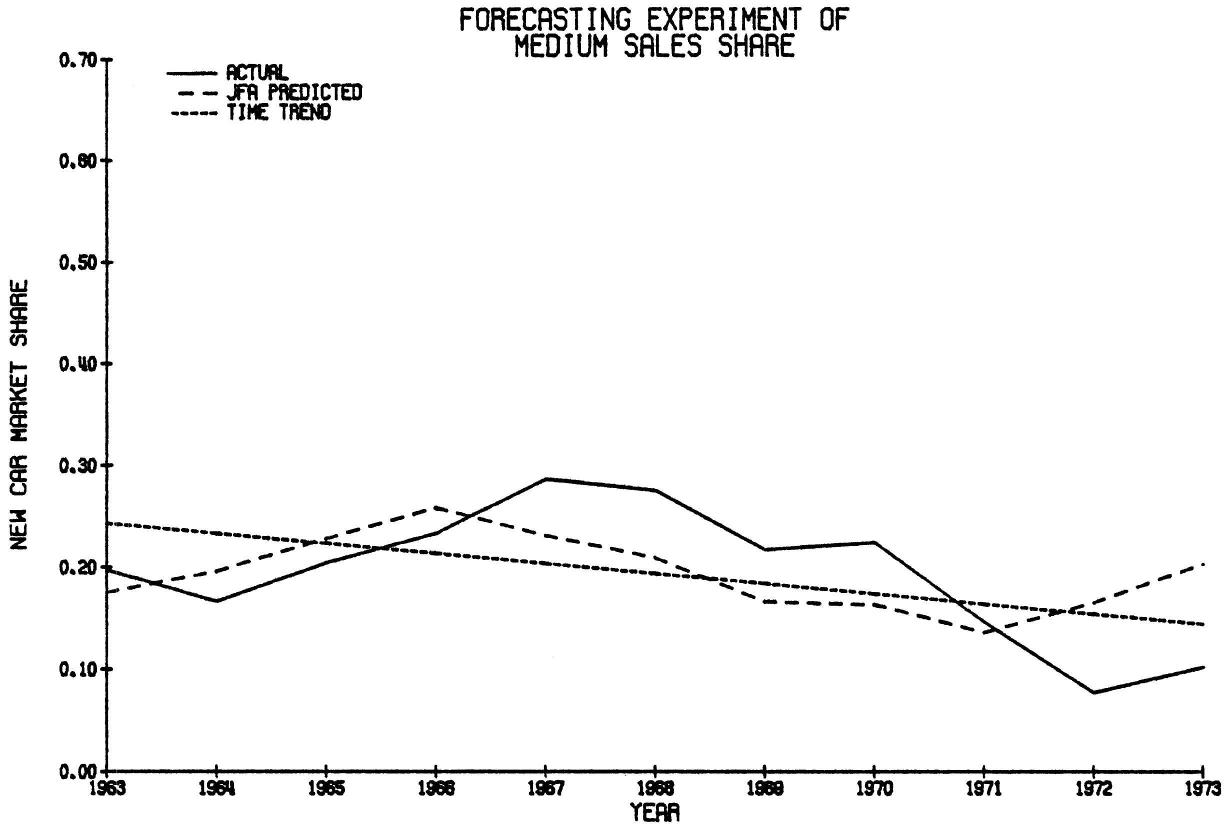


FIGURE 6-32

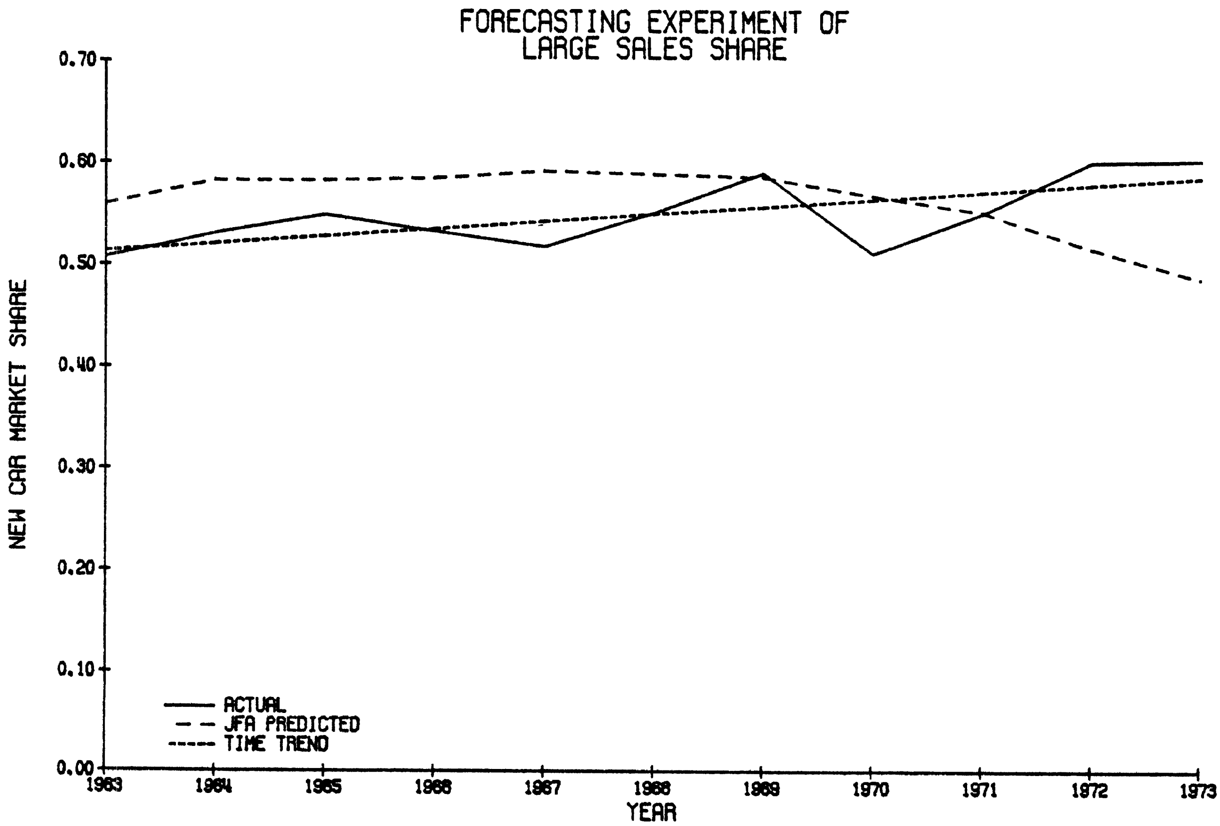


TABLE 6-12

WITHIN-SAMPLE PERIOD MEAN SQUARE ERROR TEST
FOR FAUCETT AND NAIVE TIME-SERIES MODELS

Variable	$MSE_{Faucett}$	$MSE_{time\ trend}$	r^2	Test Statistic (T_{MSE})
Sales	7.149×10^{11}	3.617×10^{11}	0.59	1.63
VMT	746.9	254.4	0.73	3.26*
Gas Consumption	14.42×10^{6}	2.544×10^{6}	0.06	3.04*
Scrappage	3.429×10^{11}	2.445×10^{11}	0.60	0.80
Cars in Use	14.45×10^{11}	3.819×10^{11}	0.01	2.15
Small car market share	.0019	.0024	0.17	-0.32
Medium car market share	.0031	.0030	0.63	0.14
Large car market share	.0037	.0006	0.27	3.74*

*Significant at the 0.05 level. The critical value for the test statistic for 9 degrees of freedom using the two-tailed Student's t statistic at the 0.05 level is 2.262. The one-tailed test statistic at the 0.05 level is 1.83.

would like to know if the MSE of the naive time trend is significantly different from that of the Faucett model.

As mentioned earlier, no exact small sample classical test for this hypothesis exists. However, one can obtain an insight into the MSE comparison by assuming that these forecast errors are normally and independently distributed with mean zero and variance-covariance matrix ϕ.

It is well known that the covariance between the sum of two variables and the difference between those variables is equal to the difference between the individual variances. Thus, the correlation between the sum and difference of the error terms is zero if and only if the MSEs are equal. One can thus derive an approximate test statistic for the hypothesis that the MSE's of the two models are equal. The alternative hypothesis is that the time trend and Faucett model do not have statistically equal MSEs. The statistical test of this hypothesis was derived from tests developed for the comparison of sample variances (Kruskal and Tanur 1978; Howrey 1978). The test statistic can be written as (17):

$$T_{MSE} = \frac{(MSE_T - MSE_F)\sqrt{n - 2}}{\sqrt{4MSE_F^2 MSE_T^2 (1 - r^2)}}$$

where

MSE_F	=	mean squared error of Faucett model
MSE_T	=	mean squared error of naive time trend
n	=	number of observations
r^2	=	sample correlation coefficient between the forecast error terms

The computed statistic measures the magnitude of the difference between the mean squared errors and the correlation between the two vectors of computed error terms. The T_{MSE} statistic is distributed, under the conditions specified, as Student's t with n-2 degrees of freedom.

As can be seen from the last column in Table 6-12, the MSE differences were large enough to reject the null hypothesis for VMT, gasoline consumption, and sales share for large cars. While the naive time trend also outperformed Faucett for new-car sales, scrappage, cars in use, and medium-car sales, that difference in performance was not large enough to reject the hypothesis that the Faucett model and a naive time trend have equal MSEs, or model performance. In the one case of small-car share the Faucett model outperformed the time trend but not by a wide enough margin to distinguish it from the time trend.

It should be remembered that these "tests" are descriptive of the exact tests of the within-sample comparative fit or performance of the two models, and that other measures have also been suggested (Theil 1961, 1966; Mincer 1969).

From these tentative results it appears that a naive time trend outperformed the Faucett model for VMT, gasoline consumption, and large-car market share. For the remainder of the variables, one cannot distinguish the Faucett model's performance within the sample period from that of a simple time trend.

6.6.4 Postsample Comparison of the Faucett Model and the Benchmark. The next question is how the two models compare in postsample forecasting performance. The data used to estimate the time trends were from the same period used to estimate the Faucett model. Individual sample periods for each time trend equation are displayed in Table 6-11. Both models were used to forecast values for 1976, 1977, and 1978. These forecasts were then subjected to the same analytic techniques previously applied to the within-sample forecasts. The numerical results are presented in Table 6-13. Figures 6-33 to 6-35 display graphs of the actual values, Faucett model forecasts, and time trend forecasts.

First, consider new-car sales. As noted in Section 6.5, the Faucett model has a DRI adjustment factor. Without this adjustment factor, the Faucett model has a much higher MSE than the one for the time trend. However, the considerable difference in relative forecasting ability of the time trend model is not large enough to reject the null hypothesis that the Faucett model without the DRI factor, and the time trend, have identical MSEs. If one lowers the confidence level from 95 to 90 percent, the time trend outperforms the Faucett model without the DRI

TABLE 6-13

1976-1978 FORECAST MEAN-SQUARE-ERROR TEST
FOR FAUCETT AND NAIVE TIME-SERIES MODEL

Variable***	MSE Faucett	MSE Time Trend	r^2	Test Statistic (T_{MSE})
Sales without DRI	104.2×10^{11}	16.04×10^{11}	0.9835	8.40**
$Sales_L$	4.412×10^{11}		0.4396	-0.97
$Sales_A$	3.250×10^{11}		0.4685	-1.21
VMT_L	21.42×10^{2}	1.329×10^{2}	0.7512	3.77
VMT_A	19.17×10^{2}		0.6310	2.91
Gas $Consumption_L$	3.483×10^{5}	190.6×10^{5}	0.0794	-3.78
Gas $Consumption_A$	3.129×10^{5}		0.0921	-4.03

*** The subscripts on the variables refer to the JFA predictions, and have the following interpretations: without DRI = the DRI factor has been removed from the forecast; L = the forecast is based on the price of leaded gasoline; A = the forecast is based on a sales-weighted average of leaded and unleaded gasoline.

* There are no values significant at the 0.05 level. The critical value for the test statistic, with one degree of freedom using the two-tailed Student's t-statistic at the 0.05 level, is ± 12.71.

** The test statistic at the 0.10 level is ± 6.31.

FIGURE 6-33

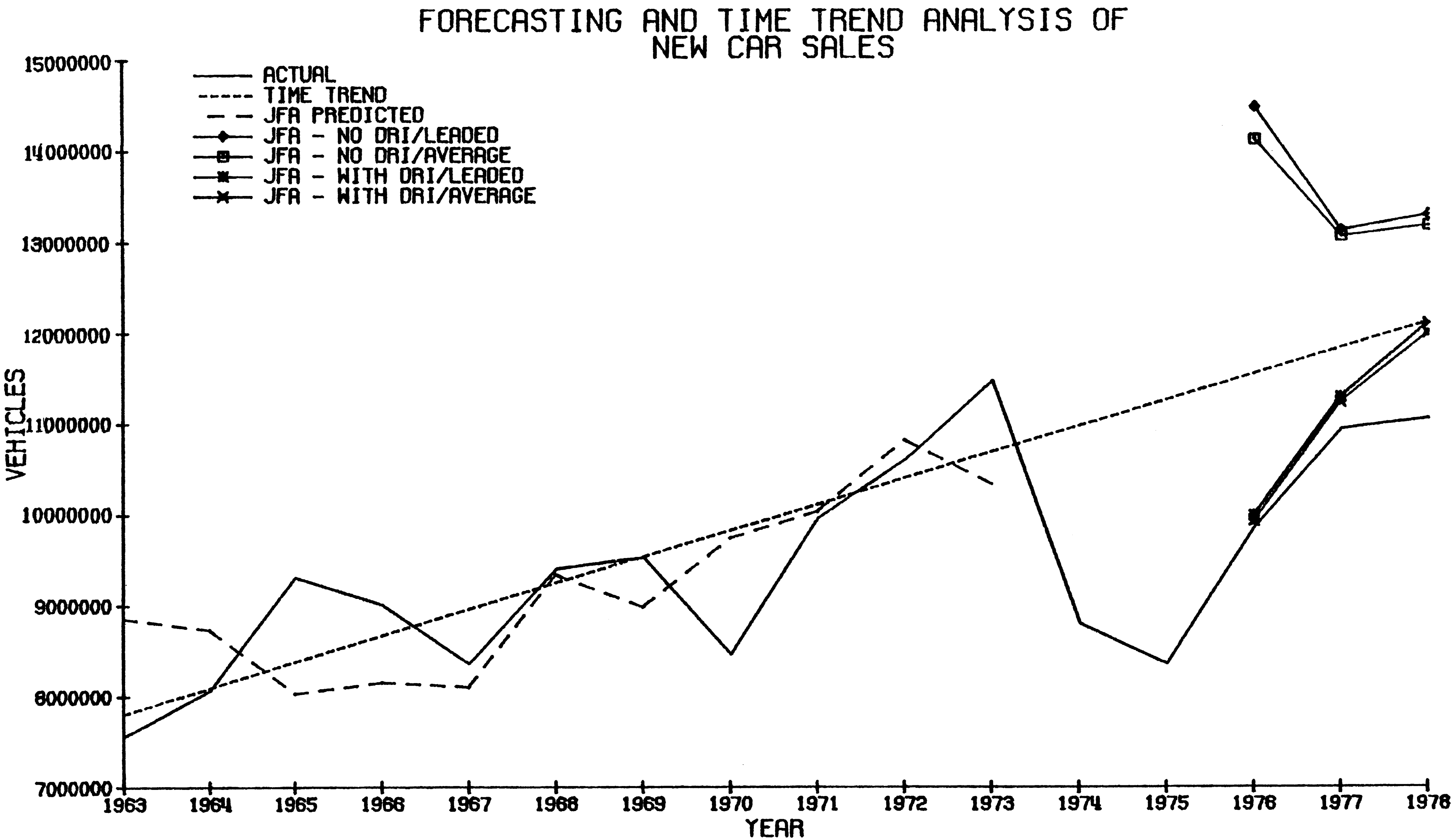

FORECASTING AND TIME TREND ANALYSIS OF NEW CAR SALES
ACTUAL
TIME TREND
JFA PREDICTED
JFA - NO DRI/LEADED
JFA - NO DRI/AVERAGE
JFA - WITH DRI/LEADED
JFA - WITH DRI/AVERAGE
VEHICLES
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
YEAR

FIGURE 6-34

FORECASTING AND TIME TREND ANALYSIS OF VEHICLE MILES TRAVELED

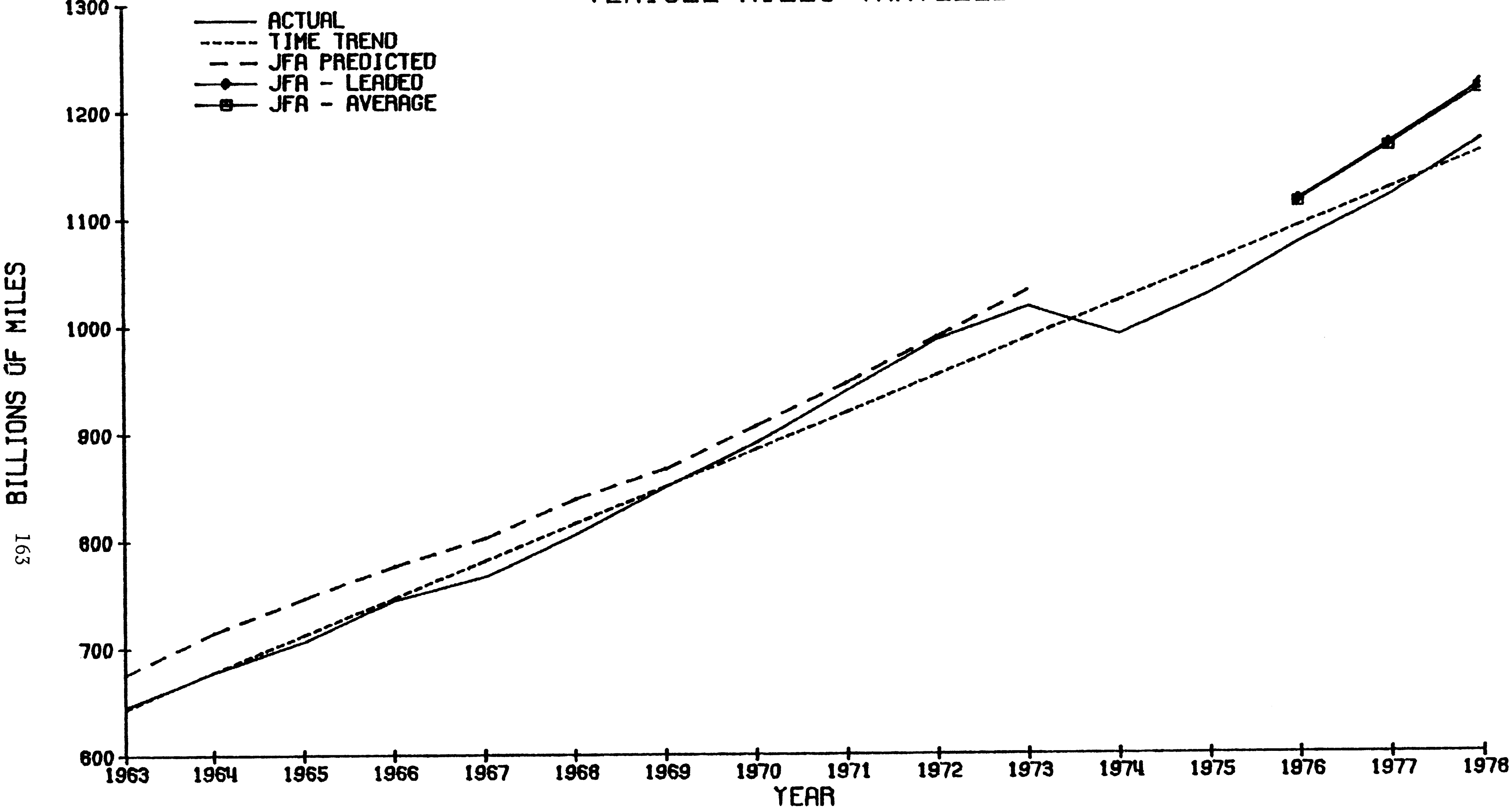
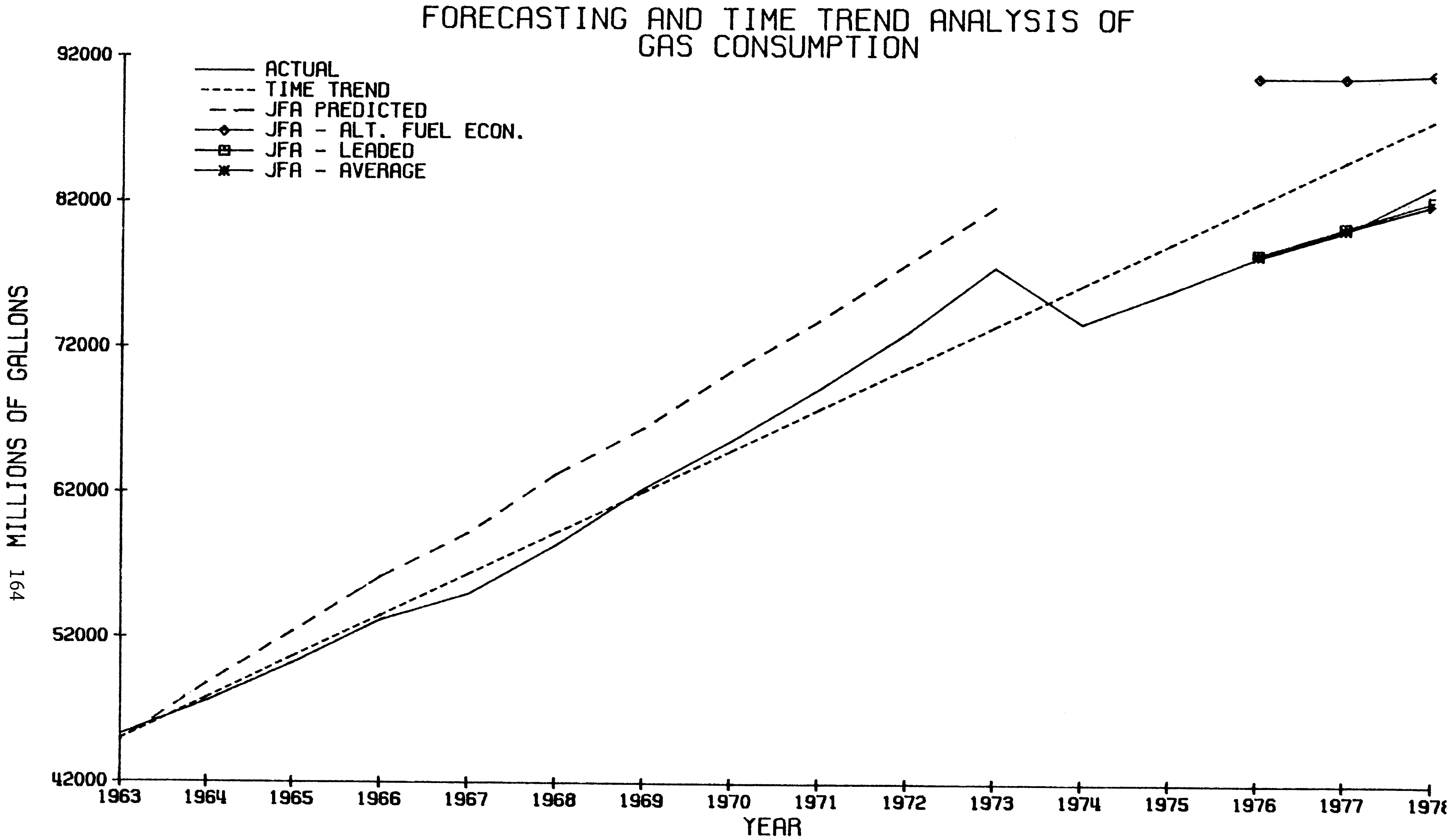


FIGURE 6-35


FORECASTING AND TIME TREND ANALYSIS OF
GAS CONSUMPTION
ACTUAL
TIME TREND
JFA PREDICTED
JFA - ALT. FUEL ECON.
JFA - LEADED
JFA - AVERAGE
92000
82000
72000
62000
52000
42000
MILLIONS OF GALLONS
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
YEAR

factor. When the DRI factor is used to adjust the Faucett forecasts, the MSE is substantially reduced. In developing the postsample forecast, it was discovered that the average fuel prices used in the Faucett model did not account for the relative increase in the consumption of unleaded gasoline. The Faucett model was subsequently exercised with new gasoline price data. The new prices are a weighted average of regular leaded and regular unleaded fuel prices using the relative consumption mix as weights. This alteration did not significantly change the model's ability to forecast new-auto sales. It is still not possible to differentiate the Faucett model's performance from a naive time trend benchmark.

VMT was also estimated using the two alternative gasoline price assumptions. First, JFA's tacit assumption was maintained. This was that leaded regular gasoline price was the correct one to use in the model. This, of course, was the assumption under which the model was estimated. Under this assumption, the Faucett model has a larger computed MSE than the time trend model. The second assumption is that the more appropriate gas price is the weighted series. This modification to the Faucett model improved its MSE. Nevertheless, its MSE continued to be larger than the one for the naive time trend, and it appears that one cannot reject the hypothesis that VMT can be forecast as accurately with a naive time trend as with the Faucett model.

Gasoline consumption was also forecast under the same two alternative assumptions. Both assumptions produce forecasts with lower MSE than the naive time trend. As in the case of VMT, gasoline consumption can be more accurately forecast using the weighted gasoline prices. However, the hypothesis that the Faucett model and the time trend have equal mean squared errors for the forecast period 1976 to 1978 cannot be rejected.

6.6.4 Intersample Comparisons of the Benchmark. The question arises as to the possible differences between the model's within-sample (1963-1973) and postsample (1976-1978) forecasting ability. One would normally expect the forecasting ability of any econometric model to weaken as the forecasting horizon lengthens. The falling precision of the model results from two causes, one economic and the other statistical. Over time, economic conditions as well as institutions and governmental influences change. Relations between economic entities are transformed as international relations undergo modification. One would expect models based on old economic conditions, relations, and institutions to be less accurate than those based on current economic realities. From a technical perspective, the confidence intervals for regression forecasts expand as the explanatory variables deviate from the mean values of the variables used to derive the estimates. The practical import of this is that one should not expect models to have as accurate predictions in the future as they seemed to have had in the past. On the average, one would expect models to have a larger MSE in the postsample period than in the sample period. Of course, if changes in the economy are included in the model on a continuous basis, then one would expect a more uniform MSE over time. At the same time, if one developed a model based on current economic conditions and those conditions differ from the past, one might expect that model to perform poorly for past economic conditions. These are some of the reasons why one must be careful in making inferences about future model performance based solely upon past and current forecasting behavior (Spivey and Wrobleski 1979).

One way to investigate the stability of the model over time is to look at MSE. If economic conditions and other factors did not change, one might expect the MSEs to be the same in the sample and postsample period. This approach has all of the same potential difficulties as those mentioned in regard to intraperiod comparisons. In addition, other problems may arise. For example, the statistical tests are most powerful when for a given total set of observations the sample sizes are approximately equal. However, equal sample sizes are rare when dealing with interperiod comparisons. In the absence of alternative methods to deal with these problems, a MSE ratio test was selected. Under the assumed conditions, the test is analogous to a two-tailed likelihood ratio test, distributed F with n_1-1 and n_2-1 degrees of freedom (df). This test is equivalent to the the well known technique of constructing the confidence interval for σ_1^2/σ_2^2 using S_1^2 as the mean square estimate of

σ_1^2 (df=N_1), and where S_2^2 is an independent estimate of σ_2^2 (df=N_2). In this case the 95% confidence interval is:

$$\left[\frac{S_1^2}{S_2^2} / F_{2.5\%} \quad (N_1;\ N_2),\ \frac{S_1^2}{S_2^2} F_{2.5\%} \quad (N_2;\ N_1)\right]$$

Note that from the origin of the F distribution

$$F_\alpha \ (N_2;\ N_1) = 1/F_{1-\alpha} \ (N_1;\ N_2)$$

and the lower percentage points for the F distribution are obtained as multiplicative reciprocals of the upper points. This is the method used by the HSRI staff. The HSRI staff hypothesizes that if economic conditions continued to be the same in the periods 1976 to 1978, as in the sample period, 1963 to 1973, then the time trend extrapolation would have the same MSE for both periods. Changing economic conditions would cause the MSE to be larger in the postsample period--that is, larger than one would expect on a statistical basis. Similarly, the Faucett model is expected to have equal MSEs if the economic conditions modeled using 1963-1973 data were the same in 1976 to 1978. Of course, if the Faucett model were not different from a time trend, these two results would be equivalent. The goal is to determine if different performances in the intrasample comparisons across models can be partially explained by different intersample results within the models.

For the time trend, the MSEs are larger in the forecast period than in the sample period for automobile sales and gasoline consumption. VMT has a smaller MSE in the forecast period. Table 6-14 displays the MSEs and the computed test statistics. (Figures 6-33 to 6-35 provide a pictorial representation.) Even though the differences in the MSEs are substantial, they are not large enough to reject the hypothesis that the time trend has the same MSE in the sample period as in the forecast period.

Because of the nature of this test, one needs to be careful about a dogmatic interpretation of the results. For auto sales and gasoline consumption, the time trend has larger computed MSEs in the forecast

TABLE 6-14

MSE COMPARISON OF INTER-PERIOD FORECASTS
FOR NAIVE TIME TREND EXTRAPOLATION

Variable	1976-1978	1963-1973	Test Statistic
Sales	19.50×10^{11}	3.62×10^{11}	5.387
VMT	132.94	254.40	0.523
Gas Consumption	19.06×10^{6}	2.54×10^{6}	7.504

*No values are significant at the 0.05 level. The critical values for the test statistic with 2 and 10 degrees of freedom using a two tailed F statistic at the 0.05 level would be 39.40 and 0.183.

period. One might quickly jump to the conclusion that without a doubt a linear trend based on the 1963 to 1973 experience would perform less well in 1976 to 1978 than it had from 1963 to 1973. Certainly the computed MSEs in the two periods provide evidence for that. However, the magnitude of the differences is not large enough and/or there are not enough observations to make that statement with statistical reliability.

6.6.5 Intersample Comparisons of the Faucett Model. The Faucett model has quite different results for the within-sample and postsample period comparison (see Figures 6-33 to 6-35). Forecasting error falls for auto sales and gasoline consumption and rises for VMT. This is the mirror image of the time trend results. Looking at Table 6-15 one sees that the Faucett model has smaller MSEs for new-car sales using the DRI adjustment and either assumption with regard to the appropriate gasoline price. The MSE is much larger if the DRI factor is not used. Even this difference is not large enough to reject the hypothesis that the Faucett model with a DRI adjustment has the same forecasting performance within the sample period as in the forecast period. Doubling the type-one probability to 0.10, one is still unable to reject the null hypothesis of equivalent MSE. (The critical values in this case would be 19.40 and 0.244.)

The large differences in gasoline consumption forecasts are significant, however. The MSEs in the forecast period are significantly smaller than those in the sample period. Given the other evidence on the Faucett model's forecasting ability (see Figures 6-33 to 6-35), this result is disturbing. Apparently the Faucett model is more consistent with the economic conditions determining gasoline consumption in the 1976 to 1978 period than in the 1963 to 1973 period. The reasons for this are unclear. Of course such a result may occur by chance, but the statistical test limits that possibility to a five percent or less probability. Postsample knowledge could have been used to derive the model, but in communications with the HSRI staff, the model authors indicated that this approach was not used.

Another reason for the higher sample-period MSE could be the HSRI

TABLE 6-15

MSE COMPARISON OF INTER-PERIOD FORECASTS OF FAUCETT MODEL

Variable	1976-1978	1963-1973	Test Statistic
New Car Sales without DRI	104.20×10^{11}	7.149×10^{11}	14.573
New Car Sales_A	3.25×10^{11}		0.455
New Car Sales_L	4.14×10^{11}		0.579
VMT_A	1917.56	746.93	2.567
VMT_L	2141.84		2.868
Gasoline Consumption_A	0.51×10^{6}	14.42×10^{6}	0.036*
Gasoline Consumption_L	0.35×10^{6}		0.024*

*Significantly different at the 0.05 level. The critical values for the test statistic with 2 and 10 degrees of freedom using a two tailed F statistic at the 0.05 level are 39.40 and 0.183.

staff's construction of data and preparation of the model to run over the sample period. This preparation was based on considerations of costs and reasonableness, and is documented in Sections 5.13 and 6.1. An examination of the forecasting performance of gasoline consumption over the sample period provides an indication of the reliability of the HSRI staff's preparation of the model. The forecasts of this variable in the earlier years of the sample period are more dependent upon the data constructed by the HSRI staff than are the later years. The later-year forecasts are increasingly dependent on the data supplied by the model authors. Yet, these earlier years are forecast relatively more accurately (see Figure 6-35). A second indication of the reliability of the HSRI staff's preparation of the model is the consistency of the gasoline consumption forecasts over the sample period (see Figure 6-35, JFA Predicted). If the HSRI staff had incorrectly prepared the model (including data construction), one would expect the slope of the curve to change over time as actual data superseded the poorly constructed data. However, the curve is smooth, and not erratic, indicating that the HSRI staff's predictions were not in serious error. The HSRI staff conclude that the significantly higher MSE in the sample period was probably not attributable to the preparation of the model for that period.

A final source of the peculiar gasoline consumption MSEs might be the different treatments of fuel economies and gasoline consumption in the simulations over sample and postsample periods. As noted in Section 5.12, different fuel economies are used for the 1963 to 1973 year vehicles in these two simulations. (These vehicles exist during both periods because some 1963 vehicles are assumed to be on the road in 1976.) The fuel economies for the postsample forecast are approximately twenty percent higher than those used in the sample period. (Recall that this was the case for the 8/77 version of the model only and that the reasons for this discrepancy are unknown to the HSRI staff.) Furthermore, unlike the sample-period forecasts, the postsample period gasoline consumption forecasts are adjusted upwards by fourteen percent. This fourteen percent adjustment factor is based on the differences between EPA and on-road fuel economies (see Section 5.11). These postsample modifications in the 8/77 version of the model have the net effect of decreasing gasoline consumption below what it would have been otherwise. Given the general overprediction of gasoline consumption during the sample period, modifications that reduce the gasoline consumption forecasts are expected to improve the model's postsample forecasting accuracy.

As an experiment, the HSRI staff simulated the 1976 to 1978 postsample period using the same inputs as before with the exception of subfleet fuel economies for the pre-1976 automobiles. For the experiment, the HSRI staff chose to use the set of subfleet fuel economies present in the other versions of the model (see Section 5.12 and Table 5-2). While this alternative set is not exactly the same as that set used in the sample period simulations, the values are adequate approximations and provide an indication of the impact of using a different set of fuel economies. The alternative set was chosen for two additional reasons. First, it contained values for 1974 and 1975, which the sample period did not. Second and more importantly, the users of the versions other than the 8/77 version may benefit from an examination of the model's forecasting ability when the alternative set of subfleet fuel economies are used in the simulation. When the alternative set of fuel economies is used as inputs to the model, the gasoline consumption forecasts for 1976, 1977, and 1978 are 90743, 90769, and 91012 in millions of gallons, respectively. These are plotted in Figure 6-35 as "JFA-ALT. FUEL ECON." The gasoline consumption forecasts based on the alternative set of fuel economies are, on average, 12.9% higher than those forecasts based on the 8/77 set of fuel economies. The MSE for the gasoline consumption forecasts based on the alternative set is 107.62×10^6 and is higher (but not significantly higher) than the sample period MSE which is 14.42×10^6. The results of the experiment indicate that the set of subfleet fuel economies used in the 8/77 version of the model significantly improves the forecasting performance of the model over the 1976 to 1978 period. Based on the experiment, the use of a different set of subfleet fuel economies in the 8/77 version of the model appears to be the principal cause of the peculiar MSEs.

A final note on gasoline consumption concerns the fourteen percent adjustment factor in ex ante forecasting. Given the relatively higher subfleet fuel economies contained in the 8/77 version of the model, the adjustment factor plays an important role of increasing gasoline consumption and making the short-term forecasts more accurate than would be otherwise. However, in the versions of the model using the alternative set of subfleet fuel economies, the adjustment factor introduces error by increasing otherwise accurate forecasts by fourteen percent. Those model users exercising the versions of the model containing the alternative set of subfleet fuel economies may want to consider the elimination of the adjustment factor from those versions.

The final interperiod comparison concerns VMT. The Faucett model has higher MSEs in the postsample period than in the sample period, as expected. Those errors are not significantly different from the ones generated in the sample period.

6.6.6 Summary of the Comparison of the Faucett to a Naive Time Trend. The objective was to compare the Faucett model with a simple time trend model. Generally one finds the within-sample performance of the Faucett model to be indistinguishable from that of a naive time trend. Some of the tests might lead one to say the time trend was superior. In comparing the Faucett model's forecasting performance in the 1976 to 1978 period to a time trend, the Faucett model was found to perform better than the time trend for new-car sales and gasoline consumption. The Faucett model performed worse for VMT. However, the Faucett model's performance was not statistically superior to that of the time trend. Also, the time trend forecasts of auto sales did significantly better than did the Faucett model, in this period, if the DRI adjustment factor was omitted.

Finally, one cannot be sure the trends that were evident in 1963 to 1973 changed in 1976 to 1978. Some evidence exists that the naive time trends did not work as well for the postsample period as they did in the within-sample period; but the evidence in that regard is not overwhelming. The Faucett model seems to have generated the same MSEs in both periods. However, the forecast errors are significantly lower for gasoline consumption in the postsample period than in the within-sample period. One explanation of this peculiar result is the HSRI staff's use of different sets of subfleet fuel economies as input to the model in the two forecasting periods. When the model is run using similar fuel economies in both the sample and postsample periods, the postsample MSE is higher than the sample-period MSE. These results indicate that the model's gasoline consumption forecasts are sensitive to the set of subfleet fuel economies used in the simulation.

6.7 Summary of the Analysis of the Forecasting Behavior

The Faucett model was studied by performing experiments to assess the Demand Block's forecasting behavior over the historical period 1963-1973, and an ex ante forecasting experiment with the full model over the 1976-1978 period. The computer program for the Faucett model was written in such a way that, without some modification, the model could not have been tested in a historical simulation, that is, by ex post forecasting. The HSRI staff made some minor changes in the program for this purpose. Two significantly modified versions of the model were also tested to see if the model's forecast could be improved. One corrected version of the model attempts to bring the computer program more into line with the model documentation. The other version changed the program so that in the market shares equation, average generalized price was no longer a constant but a function of lagged market shares.

The first experiment examined the forecasting accuracy of the Demand Block over the 1963-1973 portion of the sample period. The error statistics show that the Demand Block forecasts have %RMSEs of 9.14 for new-cars sales, 8.89 for scrappage, 3.33 for VMT, 6.35 for gasoline consumption, and 11.03 to 28.89 for the three size-class shares. Another econometric model (Luckey 1978) produced quarterly forecasts of sales and scrappage with %RMSEs of 3.9 and 0.3, respectively, over the 1961-1973 period. The Faucett model's forecasts of VMT and gasoline consumption are biased upward. The two alternative versions of the model tried by the HSRI staff succeed in improving the forecast accuracy for some variables but simultaneously reduce the accuracy for others.

The second and third experiments indicated that some variables are persistently over- or underpredicted for half-sample periods. Dividing the 1963-1973 sample period in half revealed no relevant economic and demographic differences between the two halves of the sample period, which are unaccounted for by the Demand Block, however.

The fourth experiment revealed that new-car sales, scrappage, and VMT forecasts do not tend to accumulate errors as the forecasting horizon is lengthened. The forecasts of cars in use, and large and medium-size car market shares do tend to accumulate errors. The magnitudes of the gasoline consumption forecasts monotonically increase or decrease, apparently depending on the level of gasoline prices as the forecast horizon is lengthened.

In the fifth experiment, ex ante forecasting, two questionable procedures that improve the short-run forecasting accuracy of the model were discovered. The first procedure modifies the model's highly inaccurate new-car sales forecasts by making them equivalent to DRI forecasts. The second procedure, apparently a simple error, decreases the short-run accuracy of the VMT forecast, while increasing that of the gasoline consumption forecast. The ex ante experiment is by far the most important. Any model is expected to perform well over the sample period; performing well in the future is much more difficult. Without the DRI factor, the model forecasts new-car sales with approximately a 47% error in 1976, a 20% error in 1977 and a 20% in 1978. When the HSRI staff made several corrections to the model, the results were mixed. However, the corrected version with variable average generalized price forecast new-car sales with approximately 18% error in 1976, 9% error in 1977, and 11% error in 1978.

Over the 1963-1973 portion of the sample period, a statistical test indicates that a naive time trend forecasts VMT, gasoline consumption, and large-car market share with significantly lower MSEs than does the Faucett model. For the remaining variables, the forecasts of model and time trend are statistically indistinguishable at the 95% confidence level.

Over the postsample period, the Faucett model's forecasts of sales, VMT, and gasoline consumption are indistinguishable from the forecasts of a time trend at the 95% confidence level. Without the DRI factor, the model's sales forecast is indicated at the 90% confidence level to be outperformed by a time trend. The available data are inadequate to test the forecasts of the remaining variables.

Comparison of sample- and postsample-period forecasting performance provides some evidence that the time trend performs less well in the postsample period. The Faucett model's performance does not significantly differ between the two periods, except for gasoline consumption, which has a significantly lower (0.05% level) MSE over the postsample period. These gasoline consumption MSEs are peculiar. One explanation of the gasoline consumption MSEs is the HSRI staff's use of different sets of subfleet fuel economies in forecasting over the sample and postsample periods. (HSRI staff identified three different sets of fuel economies that JFA had developed; for each experiment, HSRI used the appropriate data set.) These results suggest that users of the model should be aware of the fuel economy assumptions in the version of the model they are using. Because different subfleet fuel economies are available in the different versions of the model and because they have a significant impact on the gasoline consumption forecasts, the HSRI staff would caution users of the model about relying on that postsample forecasting experiment as an indication of the model's future-year forecasting accuracy.

7.0 SENSITIVITY ANALYSIS OF THE DEMAND BLOCK

7.1 Introduction

Sensitivity analysis may be defined as an attempt to measure the responsiveness of the model's forecasts of endogenous variables to changes made in the model's exogenous variables, parameters, or assumptions. The sensitivity analysis of the Demand Block was limited to analyzing the impacts of changes in several of the exogenous variables, and a change in the market share normalization procedure. This analysis was generally accomplished using multiplier experiments, so called because the behavior of the dependent variable is expressed as a response to the independent variable multiplied by some constant factor. For example, in one experiment, the vector of new-car prices is multiplied by 1.1. That is, each of the car prices was increased by 10% as compared to its baseline values. The objective is to simulate a single shift in an exogenous variable that is sustained throughout the remaining periods of the forecast. It should be emphasized that when the constant percentage rate, for example, a 10% increase in price, is applied, it is not equivalent to a compound growth or inflation rate of 10%. Rather, the sensitivity analysis is performed by multiplying each year's base (actual) prices by 1.1. In the case of auto prices, real prices were generally falling during the sample period and the multiplicative (sensitivity) factor resulted in real prices falling less than they would have otherwise.

These experiments were performed with the uncorrected JFA version of the model over the sample period, 1963 to 1973. Actual values are used for all exogenous variables except the multiplier variable. That variable was changed by a constant percentage for the entire sample period.

Detailed results of the multiplier experiments are presented in the tables of Appendix E. Each table includes four columns: CONTROL, SHOCK, DIFFERENCE, and % DIFF. The forecast values generated using the base (actual) values of the exogenous variables are listed in the CONTROL column (these are identical to the ex post forecasts of Section 6.2). Corresponding values generated when the multiplier variable is changed are listed in the SHOCK column. The DIFFERENCE column lists the difference between the shock and control values, while % DIFF refers to the percentage difference with respect to the control value.

7.2 Changes in the Exogenous Variables

The sensitivity of the forecasts for eight key variables was examined. These variables are: new-car sales; scrappage; VMT; gasoline consumption; total automobile stock; and market shares of small, medium, and large new cars. The exogenous variables considered in the multiplier experiments are unemployment rate, disposable income, population (number of households), new-car price, and gasoline price. The HSRI staff considered these exogenous variables to have the most important impacts on the automobile market.

Separate multiplier experiments were performed with:

- one percentage point higher unemployment rate accompanied by one percent lower disposable income and target stock
- one percent larger population and one percent larger target stock
- ten percent higher net price of small cars
- ten percent higher net price of medium cars
- ten percent higher net price of large cars
- ten percent higher net price of all cars
- ten percent higher fuel price
- 100% higher fuel price

Again, it should be noted that the exogenous variables are not just higher in the first year, but are higher in all the years in the period (1963-1973) over which the multiplier experiments are run.

Except for the first two, the multiplier experiments are relatively straightforward. In the first experiment the HSRI staff allowed for the inverse relationship between unemployment and disposable income. The relationship assumed is that a one percentage point higher unemployment rate occurs concurrently with a disposable income decrease of one percent. Moreover, a one percent lower disposable income was assumed to imply that target (desired) stock, a function of income and household population, is one percent lower. In the second experiment, a one percent larger household population is assumed to imply a one percent greater target stock since average autos per household over the period 1954-1975 is approximately one (see Table 4-15).

The results of the multiplier experiments are presented in Tables E-1 to E-57 in Appendix E. The impacts of changes in the price variables interpreted as price elasticities are in Table 7-1.

When interpreting the multiplier experiments, one should consider them to be N-period impact elasticities. As an illustrative example, consider the experiment where all auto prices are increased by 10% and the simple share normalization equation is used (as explained in Section 7.3). (The results of this experiment appear in Table 7-1.) The elasticity of -1.0647 in the first period would be interpreted as follows: in the first period equilibrium that results from the 10% increase in all auto prices, new-car sales are predicted to be 10.65% lower than they would be "otherwise." What is meant by "otherwise" is the forecast that is produced by using base (actual) values of all exogenous variables including auto prices. The 1973 value of -0.1254 should be interpreted as an 11th period impact elasticity. In this case, the auto prices for the 10 previous years as well as the prices in the 11th are increased by 10% over their base values. In the 11th year, or 1973, the 10% higher level of prices results in new-car sales being 1.25% lower than than they would be otherwise.

In effect, the multiplier experiments compare the within-sample forecast sensitivity to simulated sustained changes in individual exogenous variables. These forecasts are compared to forecasts generated by the unaltered base values. In this way, the N-period impact elasticities that are presented in Table 7-1 are computed as the percentage change in the

TABLE 7-1

ELASTICITIES

VARIABLE		SMALL NET PRICE	MEDIUM NET PRICE	LARGE NET PRICE	ALL NET PRICE	FUEL PRICE (10%)*	FUEL PRICE (100%)*	WITH SIMPLE NORMALIZATION PROCEDURE ALL NET PRICE	WITH SIMPLE NORMALIZATION PROCEDURE FUEL PRICE (100%)
NEW CAR SALES	1963	-0.3178	-0.2043	-0.7117	-1.2307	-0.5499	-0.39547	-1.0647	-0.34495
	1968	-0.1187	-0.1759	-0.2679	-0.6659	-0.2843	-0.28170	-0.3540	-0.17520
	1973	0.0148	0.0042	0.1391	0.0436	0.0215	-0.20093	-0.1254	-0.07630
SCRAPPAGE	1963	-0.0552	-0.0405	-0.1003	-0.1960	0	0	-0.1960	0
	1968	-0.0175	-0.0204	-0.0552	-0.0980	-0.0417	-0.03387	-0.0799	-0.02834
	1973	-0.1063	-0.1445	-0.3065	-0.6168	-0.2430	-0.22099	-0.4420	-0.16428
VMT	1963	-0.0236	-0.0142	-0.0516	-0.0888	-0.1192	-0.08626	-0.0776	-0.08270
	1968	-0.0441	-0.0746	-0.1292	-0.2832	-0.1890	-0.16292	-0.1806	-0.12936
	1973	-0.0489	-0.0717	-0.0559	-0.2339	-0.1550	-0.17946	-0.0875	-0.10877
GAS CONSUMPTION	1963	-0.0155	-0.0230	-0.0845	-0.1265	-0.1350	-0.09823	-0.1262	-0.09833
	1968	0.0210	-0.0326	-0.1761	-0.2317	-0.1609	-0.15052	-0.2441	-0.15324
	1973	0.0714	0.0705	-0.1332	-0.0659	-0.0700	-0.12746	-0.1808	-0.14165
CARS IN USE	1963	-0.0397	-0.0250	-0.0912	-0.1555	-0.0780	-0.05609	-0.1370	-0.05053
	1968	-0.0726	-0.1303	-0.2383	-0.5055	-0.2186	-0.20559	-0.3301	-0.14937
	1973	-0.0764	-0.1162	-0.1099	-0.4085	-0.1635	-0.24055	-0.1699	-0.12241
SMALL CAR MARKET SHARE	1963	-1.1402	0.4467	0.1041	-0.4579	-0.1913	-0.19295	0.1815	0.10539
	1968	-2.2626	0.6515	0.3056	-0.9959	-0.3812	-0.30611	0.3240	0.24187
	1973	-1.9516	-0.0130	0.3989	-1.0605	-0.4771	-0.35676	0.5342	0.25861
MEDIUM CAR MARKET SHARE	1963	1.8303	-2.2149	0.2543	-0.3772	-0.2551	-0.22123	0.3677	0.06666
	1968	2.6739	-3.6416	0.6480	-1.0273	-0.6594	-0.43914	0.5419	0.02959
	1973	3.1321	-3.0683	0.4698	-0.5622	-0.4240	-0.34418	0.4715	0.06614
LARGE CAR MARKET SHARE	1963	-0.0288	0.4785	-0.1288	0.3355	0.1706	0.16078	-0.2158	-0.09013
	1968	-0.1690	1.0692	-0.3358	0.7090	0.3660	0.26176	-0.4778	-0.14358
	1973	-0.0611	1.2933	-0.4524	0.9150	0.4833	0.37276	-0.4618	-0.16599

* All elasticities are in terms of a response to a one percent change in the exogenous variable. For fuel price, two experiments were performed (one with a 10% higher, and the other with a 100% higher, fuel price) because the elasticities were expected to be different when measured at the second, much higher, price level.

forecast of an endogenous variable (listed in the top row of Table 7-1) that results from a one percent change in the exogenous variable (listed in first column).

7.2.1 Unemployment Rate, Disposable Income, and Target Stock. (Tables E-1 to E-5).

This experiment examines the responsiveness of the Demand Block's outputs to a one percentage point increase in unemployment, concurrent with a one percent decline in both disposable income and target stock. Scrappage is modeled as a function of the unemployment rate, and, as expected, a higher unemployment rate produces lower scrappage forecasts. A one percentage point higher unemployment rate results in a 4.1% lower scrappage in the first year. In the 10th and 11th periods of the forecast (after 1971) scrappage is more than 2% below the control values; that is, cars have a greater life expectancy. Between 1967 and 1970 scrappage is relatively higher than in other years because cars not scrapped during the 1963-1966 period subsequently enter the age groups with higher scrappage rates.

New-car sales is modeled as a function of target stock and scrappage. Lower target stock and scrappage yield lower new-car sales forecasts. New-car sales is 3.4% lower in the first year, but this difference gradually decreases, then begins to increase, and in the 10th and 11th years is lower by slightly more than 2%. Since the absolute decrease in new-cars sales is greater than the absolute decrease in scrappage, total auto stock (cars in use) is lower. Due to the lower total auto stock and disposable income, VMT is lower. The decrease in VMT is less than 1%. Gas consumption is also lower by less than 1%.

The market shares forecasts do not change since the share equations depend only on generalized price by class and on lagged shares. Economic theory suggests that a small temporary increase in the unemployment rate might have no effect on market shares, but a persistent increase in unemployment is more likely to alter consumer behavior. Because unemployment does not enter the market shares equations, this model is incapable of handling such potential changes in market shares.

7.2.2 One Percent Larger Population and Target Stock. (Tables E-6 to E-10).

The results of the multiplier experiment, in which the population and target stock are both increased by one percent, are as expected. In the first year the new-car sales forecast is 2.1% higher, then declines to about .5% higher before rising to about 1% higher in the 10th and 11th years, compared to the control forecast. Scrappage is higher in each successive year, because there are more cars in use in each successive year. The difference between the control and shock values of VMT ranges from a 4.0 billion mile increase in 1963 to a 9.5 billion mile increase in 1973, while the difference for gasoline consumption ranges from 303 million gallons in 1963 to 753 million gallons in 1973. While these absolute differences may seem quite large, the percentage differences for both variables are always less than 1%. For VMT the percentage difference generally increases from 1963 to 1973. For gasoline consumption the percentage difference stabilizes at just under 1%.

7.2.3 Ten Percent Higher Net Price For Small Cars. (Tables E-11 to E-18.)

The results from this experiment indicate that a ten percent higher price for small cars produces a 3.2% lower new-car sales forecast in the first year. After ten years, the new-car sales forecasts differ from the control values negligibly. That is, after the second year new-car sales are relatively inelastic with respect to small-car prices (although the pattern of differences in Table E-11 also suggests a possibly cyclical response by the model). Consumers merely shift from small to medium size cars. From 1963 to 1973 the small-car market share impact elasticity is an average of -1.97, while the medium-car market share cross-elasticity is an average of 2.76. These estimates of the elasticities seem inordinately high. Surprisingly, the large-car share cross-elasticity is negative, but this is due solely to the normalization process (explained in detail in Section 4.4) for the shares. The other variables are negligibly affected, and have impact elasticities smaller in absolute value than 0.1.

7.2.4 Ten Percent Higher Net Price of Medium Cars. (Tables E-19 to E-26.)

As with the previous experiment, total new-car sales are almost imperceptibly affected by the 10% increase in medium-car prices in the 10th and 11th periods of the forecast. As expected, the market share forecasts for medium cars are lower, while the market share forecasts for small and large cars are higher. The average impact elasticity of the medium-car share over the 1963 to 1973 period is -3.26 and seems large. In the first year, the cross-elasticity of the small- and large-car shares are about the same, 0.45. In the later periods of the forecast, however, the cross-elasticity of the small-car share falls below zero, while that of the large-car share reaches 1.3. That is, during the last part of the forecast period, consumers trade up, and the small-car share actually decreases, though not substantially.

7.2.5 Ten Percent Higher Net Price for Large Cars. (Tables E-27 to E-34.)

In this experiment, the prices of large cars are increased by 10%. The model's sensitivity to large-car price differs substantially from the model's sensitivity to the prices of the other size cars. The first year elasticity of total sales is relatively high, -0.7. However, in the 10th and 11th years of the forecast the impact elasticity of total sales is slightly positive (about 0.15). Although the 1973 elasticities of total sales with respect to the prices of the other classes are also positive, they are closer to zero than the large-car price result. Clearly, however, economic theory provides no support for these positive price elasticities and the best that can be said for the model is that these estimates are probably not statistically different from zero or even from small negative values. An explanation, in terms of the model's structure, is that the impact of higher prices is eventually offset by the increase in the gap between the target (desired) stock and the actual stock. Since target stock is a function of only income and population, the gap increases over time due to the negative price impact on new-car sales. (Scrappage is negatively affected by higher prices, but its impact on the gap is relatively small.) During the early periods of the forecast, the price effect dominates and new-car sales are lower. By the 10th or 11th year, the gap term dominates, and new-car sales are above the level of the baseline forecast. Thus, the model produces positive price elasticities.

From 1963 to 1973 the price elasticity of the large-car share steadily increases in magnitude from -0.13 to -0.45. The cross-price elasticity of the medium-car share first increases and then decreases to 0.47 by 1973. The cross-price elasticity of the small-car share is also positive, and in the last 3 years of the forecast the size of the small-car share increases more than that of the medium-car share. The difference in small-car share is not a direct result of the higher large-car price, however, but a result of the normalization process. As with the previous two experiments, the new-car price increase lowers VMT relative to the baseline in each year.

7.2.6 Ten Percent Higher Net Price for All Cars. (Tables E-35 to E-42.)

When prices of new cars (as simulated by the Industry/Policy Block) are multiplied by 1.1 for each of the 11 sample years, the largest impact occurs in the early years. The one-year-impact elasticity of new-car sales is -1.23 indicating that a 12.3% reduction in unit auto sales results from a 10% increase in price when compared to the control forecast. The elasticity falls in absolute magnitude over time. After 5 years the 10% price incease results in a 6.49% reduction in sales as compared to the control forecast. The 11th year impact elasticity has a positive value of 0.0436, indicating that an increase of four-tenths of one percent in unit auto sales results from a sustained 10% increase in new-auto prices. As noted in the previous section, this positive elasticity can be linked to the relationship between sales, prices, and the gap between target and existing vehicle stocks.

The market shares of small and medium cars are lower while the market share of large cars is higher. This indicates that the large-car share is less price sensitive (i.e., less price elastic) than the medium- and small-car shares. The large-car share is so much higher, however, that the number of large cars sold is higher (for 1967-1973) due to the higher prices of all cars, which is unrealistic. In 1972, for example, large-car sales are more than eight percent higher with the higher net prices. As expected, the impact elasticities of scrappage with respect to all car prices are much larger in magnitude than with respect to each price separately. Similarly, the elasticity of cars in use is also more sizeable, reaching -0.56 in 1970. Both VMT and gasoline consumption have negative elasticities.

7.2.7 Ten Percent Higher Fuel Price. (Tables E-43 to E-50.)

The effects of a higher fuel price are similar to the effects of higher new-car prices for all variables. Both effects operate through a higher generalized price, but in different proportions because net price and operating cost account for different proportions of generalized price. New-car sales is 5.5% lower the first year, but in the 10th and 11th years the differences are quite small. The elasticities of sales with respect to fuel price in the 10th and 11th years are positive, though quite small. Scrappage is lower. The market shares of small and medium cars are smaller, and the market share of large cars is correspondingly larger. In other words, the large-car share is less sensitive to higher fuel prices than are the other two shares. As in the previous experiment, the number of large cars sold is higher relative to the control forecast in some years, which is just as unrealistic a result of higher fuel price as it is of higher net prices. VMT is directly affected by operating cost and is lower. The impact elasticity of VMT with respect to fuel price is between -0.2 and -0.15 for all but the first two years. Gasoline consumption is lower because VMT is lower.

The responses of sales and market shares criticized above might conceivably occur in the real world, where owners of gas guzzlers traded in for more fuel-efficient new large cars, for instance, but the model does not account for these types of responses.

7.2.8 <u>100% Higher Fuel Price</u>. (Tables E-51 to E-57.)

The results of this experiment are similar to those for the 10% higher fuel price despite the larger shocks. Most of the estimated elasticities vary little between the 10% and 100% experiments. However, in the 100% experiment the 11th year elasticity of total sales is negative and equal to -0.20. Unfortunately, even with a 100% higher fuel price the Demand Block continues to produce forecasts that imply higher large-car sales. Doubling the fuel price results in a 10% higher number of large cars sold in 1973.

7.3 Changing the Normalization Procedure

Some of the anomalous results of the previous multiplier experiments can be attributed to the JFA market share normalization procedure. To investigate the effects of the normalization procedure the HSRI staff replaced the "JFA normalization procedure" with the "simple normalization procedure" (see Section 4.4.4) and performed four multiplier experiments. These experiments are:

- ten percent higher small-car net price
- ten percent higher large-car net price
- ten percent higher net prices for all classes
- 100% higher gasoline prices

(Detailed analysis of these experiments is presented in Appendix D.)

The results of these experiments indicate that under the simple normalization procedure the large-car share is more price elastic than small- and medium-car shares. This is the opposite of the results of the multiplier experiment with the JFA normalization procedure. Also, demand for VMT is less (gasoline) price elastic with the simple normalization procedure than with the JFA normalization procedure. The impacts on the forecasts of other variables also differ substantially between the two versions. Thus, the dynamic properties of the model differ depending on the normalization procedure. The potential magnitude of the differences can be suggested by the 1972 forecasts. With the simple normalization procedure, a 100% higher gasoline price results in 19% lower large-car sales, while with the JFA normalization, a 100%

higher gasoline price results in 6% higher large-car sales.

7.4 Summary of the Sensitivity Analysis of the Demand Block

The multiplier experiments indicate the sensitivity of the model to changes in the exogenous variables. As expected of a stock adjustment model, these changes have a substantial impact on the forecast level of annual new-car sales in the short run, but minor impact in the longer run. The impacts on the forecasts of the other variables tend to increase over time, which is also reasonable. Interpreting the impacts of changes in net prices and gasoline prices as impact elasticities is revealing. The own-price elasticities of gasoline demand indicated by the model are quite low, about -0.14 in the first year, changing to -0.16 by the 6th year, then becoming -0.07 in the 11th year. The 11th year impact elasticity of new-car sales with respect to various prices is indicated to be positive except in the 100% higher fuel price experiment. These incorrectly signed elasticities are of small magnitude, and can be attributed to the model's structure. These results give warning that the model user must cautiously interpret the model's output.

The market shares results are often anomalous. Some of these anomalies were traced to the JFA procedure for normalizing market shares and disappeared when a simpler procedure was employed. Even with the simpler procedure the implied own-price elasticities of gasoline remain low, less than -0.16, and the own-price elasticity of total sales has the wrong sign in some years.

8.0 SENSITIVITY ANALYSIS OF THE INDUSTRY/ POLICY BLOCK

8.1 Introduction

This section reports an analysis of the sensitivity of the Industry/Policy Block's outputs, net prices and fuel economy ratings, to changes in the policy variables and assumptions incorporated in the generalized price algorithm. The policy variables examined are gasoline price, fuel economy standards and penalties, excise taxes, and rebates. The assumptions studied are technological add-on costs, the perceived lifetime miles per car parameters, and the value of the scale factor (VALGPM) in the excise tax/rebate option. (VALGPM is an approximation used to scale the units in which additional costs are calculated in the generalized-cost-minimizing algorithm.)

The multiplier experiments were performed using the entire model over the postsample period, 1976 to 1985. The postsample period was selected because it is the period over which the algorithm is designed to perform and because it is critical for policy analysis. These experiments were performed using the entire model, because the Industry/Policy Block is dependent on market shares, as forecast by the Demand Block. However, the impacts of the parameter or variable changes are examined only in terms of Industry/Policy Block outputs, net prices and fuel economy ratings.

The multiplier experiments compare forecasts generated with a set of baseline assumptions (those of the model authors) to forecasts generated with alternative assumptions. The baseline assumptions were used to determine a base case for each policy option. Some multiplier experiments were performed under each of the policy options; others pertain to a particular option. The following experiments were performed:

- 100% higher gasoline price

- 50% higher perceived lifetime miles driven per car parameter
- 10% higher parameters of the technological add-on cost curve
- 25% higher standard (Standard/Penalty option only)
- 100% higher penalty (Standard/Penalty option only)
- 100% higher excise taxes (Excise Tax/Rebate option only)
- VALGPM corresponding to zero point (Excise Tax/Rebate option only)

Detailed results are presented in Appendix F, Tables F-1 to F-78.

8.2 <u>100% Higher Gasoline Price</u> (Tables F-1 to F-18)

The baseline assumptions specify gasoline prices of \$.502 and \$.501 (\$1974) for 1976 and 1977 respectively, and that thereafter price rises 1.1 cents per year through 1985. This multiplier experiment examines the impact of doubling those real gasoline prices.

The Industry/Policy Block responds to the 100% higher gasoline price with higher fuel economies and higher net prices. Under the Standard/Penalty option, the increases in net prices range from \$13.35 to \$189.87 and vary over time. Fuel economies for all size-classes increase over time and are up to 9% higher than those in the base case. Under the Excise Tax/Rebate option, the changes in net prices vary over time, ranging from -\$26.45 to a +\$204.09. Fuel economies also vary over time but are generally higher than in the base case. The increases range up to 10% higher. As compared to the other two options, the response under the No-Policy option is somewhat larger and generally increases over time for both net prices and fuel economies. However, as the fuel economies in the No-Policy option base case are lower (relative to the other base cases), the relatively larger response to the gasoline price increases still results in forecasts for 1985 that are 2 to 3 mpg below those for the Standard/Penalty and Excise Tax/Rebate options.

These Industry/Policy Block responses to higher gasoline prices indicate that new-car fuel economies are not very sensitive to gasoline prices. The average annual increases in automobile fuel economies that resulted from the higher gasoline prices are 4.63%, 4.95% and 7.31% under the Standard/Penalty, Excise Tax, and No-Policy options, respectively. The automakers' small responses to higher gasoline prices are attributed to the technological costs of attaining higher fuel economies. Each additional mpg beyond the base fuel economy costs an increasing amount. The smaller responses under the Excise Tax/Rebate and Standard/Penalty options occur because the control (baseline) solution includes the impact of the particular policy. That is, the potential policy add-on costs have already increased fuel economies in the base case.

8.3 <u>10% Higher Parameters of Technological Add-On Curve</u> (Tables F-19 to F-36)

This experiment examines the responsiveness of the outputs of the Industry/Policy Block to changes in the parameters of the technological add-on cost functions. These functions relate increase in fuel economy (over a base fuel economy) to increases in the cost of the car (over a base price). The cost functions used by JFA take the form:

$$\Delta C = \alpha \; (\Delta FE)^{\beta}$$

where

ΔC = change in costs above base price

ΔFE = change in fuel economy above base fuel economy

α, β = estimated parameters (18)

Hittman Associates (1976) predicted the values of the parameters for three years: 1980, 1985, and 1990. JFA used an interpolation technique to obtain cost functions for the intervening years. The values of the parameters (in the computer program) indicate that the cost of achieving increases in mpg decreases over time, and is constant after 1985.

The HSRI staff tested the sensitivity of fuel economies and net prices to changes in the values of the cost parameters. Both parameters (α and β) were increased by 10%. Because of the specification of the function, a

10% increase in the parameters does not increase costs uniformly by 10%. The following example provides an indication of how costs are affected: for small cars in 1980, a 1-mpg increase over base fuel economy costs $11, and a 5-mpg increase costs $275; with 10% higher parameters, these costs are $12.1 and $417.4, respectively.

The Standard/Penalty, Excise Tax/Rebate, and No-Policy options were simulated using both the model-author-supplied parameters and the ten percent higher ones. Net prices respond the least (less than 1%) under the No-Policy option, and most (less than 4.1%) under the Standard/Penalty option. Under the No-Policy option, net prices are lower and generally declining with respect to that option's base case. Under the Standard/Penalty option, prices are initially lower and then generally increasingly higher over time than its base case. Under the Excise Tax option, price changes vary but are generally higher than its base case. Under all policy options, the increased parameters result in generally lower fuel economies. In some cases the declines are as much as ten percent.

Additional experiments (not shown in the appendix) with the Standard/Penalty option reveal that the Policy Block's outputs are more responsive to a lowering of the curve's parameters. Furthermore, the Policy Block is sufficiently sensitive to the technological cost curve that if the exponential coefficient (β) alone differed greatly (e.g., when 50% larger a 5-mpg increase costs $1375 for a small car in 1980) from the baseline value, the values of the Policy Block's outputs would differ substantially (e.g., 20%).

8.4 <u>50% Higher Perceived Lifetime Miles Driven Per Car Parameter</u> (Tables F-37 to F-54)

The experiment examines the sensitivity of net price and fuel economy to changes in the perceived lifetime mileage parameter used in the calculation of average generalized price. As noted in Section 2.5, the model authors use a perceived lifetime mileage figure of 52,853. That figure is based on a 100,000 mile car life, a consumer perception factor, and a discount rate used to derive the present value of the costs of those lifetime miles. As the model does not allow the user to simulate alternatives to the assumptions implicit in the perceived lifetime figure, the HSRI staff performed a multiplier experiment increasing the model authors' figure by 50% to 79,279.5.

The impact of the higher lifetime mileage figure on the Industry/Policy Block's outputs is small under all the policy options. The largest price responses, which appear sporadically under the Excise Tax/Rebate option, are fairly small at an increase of 3%. The average annual price responses over the 1976-1985 period are 0.891%, 1.067%, and 1.404% under the Standard/Penalty, Excise Tax/Rebate, and No-Policy options, respectively. The response of fuel economy to the higher mileage parameter is also small. Those average annual responses are 2.267%, 3.022% and 3.938% under the Standard/Penalty, Excise Tax/Rebate, and No-Policy options, respectively. These responses suggest that fuel economies and net prices are not responsive to changes in either the discount rate or the perception factor.

8.5 <u>25% Higher Standard</u> (Tables F-55 to F-60)

This experiment examines the impact of setting the corporate average fuel economy standards 25% higher than those established by the Energy Policy and Conservation Act (EPCA) and the National Highway Traffic Safety Administration (NHTSA). This experiment is performed only with the Standard/Penalty option. The penalty level is that specified by EPCA and is the same for both levels of standards. As the standards and penalties do not apply for 1976 and 1977, the higher standards have no impact for those years. For the 1978 to 1985 period, net prices are higher and the response to the higher standards increases over time. Prices are between 12% and 20% higher in 1985. The average annual response of prices is 12.2% over the 1978-1985 period. The fuel economy response to the higher standards is weaker. These increases average 8.9% per year and are generally between 1 and 3 mpg.

8.6 100% Higher Penalty (Tables F-61 to F-66)

In this experiment, the impact of a 100% higher penalty on fuel economies and net prices is studied. The experiment is performed using the Standard/Penalty option only. The base case standards and penalties are those of EPCA and NHTSA. The standards are the same in both cases. Neither the automobile prices nor the fuel economies are affected by the higher penalty until 1980. Small-car prices are increasingly lower over the 1980 to 1985 period. The difference grows to 5.6% in 1985. Medium-car prices are relatively unaffected, changing at most by 1%. Large-car prices increase at an increasing rate; the difference in 1985 is 8.0%. The fuel economies of all cars increase relative to the base case. The 1985 increases are 1 mpg for small cars and 2 mpg for medium and large cars. The seemingly unlikely combination of lower net price and higher fuel economy for small cars results from the higher technological costs of greater small-car fuel economy being more than offset by the negative policy add-on costs (i.e., the cross-subsidization by large-car buyers) and lower operating costs.

8.7 100% Higher Excise Tax/Rebate Schedule (Tables F-67 to F-72)

This experiment examines the impact of doubling the baseline excise tax/rebate schedule (see Table 8-1). In this experiment, both taxes and rebates are increased. When the tax/rebate schedule is doubled: small-car prices are 13 to 20% lower; medium-car prices are 3 to 10% higher, except for the first year; and large-car prices are higher (a maximum of 6%) through 1980, and generally lower thereafter. The fuel economy forecasts are generally higher, but rarely more than 10% higher. Small-car fuel economy does not respond to the higher tax/rebates for the last three years because there is no additional rebate for exceeding 30 MPG. However, small cars reach 30 MPG three years sooner with the doubled tax/rebate schedule. An odd result of the model is the forecast decline in medium-car fuel economy between 1982 and 1983. In the control forecast the decline is quite small, 0.3 MPG, but with the doubled tax/rebate the decline is 1.2 MPG, and by 1985 fuel economy remains lower than in 1980. This contradicts the common sense expectation that

TABLE 8-1

BASELINE TAX/REBATE SCHEDULE

Fuel Economy in Miles Per Gallon	Excise Tax/Rebate in 1974 Dollars
1	1998.7
2	1998.7
3	1998.7
4	1998.7
5	1998.7
6	1998.7
7	1998.7
8	1998.7
9	1998.7
10	1998.7
11	1635.3
12	1332.5
13	1076.3
14	856.61
15	666.25
16	499.69
17	352.72
18	222.08
19	105.20
20	-.0
21	-95.179
22	-181.70
23	-260.71
24	-333.13
25	-399.75
26	-461.25
27	-518.19
28	-571.07
29	-620.30
30	-666.25
31	-666.25
32	-666.25
33	-666.25
34	-666.25
35	-666.25
36	-666.25
37	-666.25
38	-666.25
39	-666.25
40	-666.25

the automakers can at least replicate a previous year's fuel economy.

8.8 VALGPM Corresponding to Zero Point (Tables F-73 to F-78)

In this experiment the impact of the model author's scale factor, VALGPM, is examined. VALGPM is an approximation used to scale the units in which additional costs are calculated in the generalized-price-minimizing algorithm. As explained in Section 3.2, VALGPM is variable in the Standard/Penalty option. However in the Excise Tax/Rebate option, this variable is set at $350, corresponding to 18.7 mpg. An alternative assumption is to set the value of VALGPM so that it corresponds to a fuel economy rating at which the excise taxes or rebates are zero (i.e., the zero point). This zero point will vary with the user-specified excise tax/rebate schedule. This experiment compares the alternative assumption with the baseline assumption of a constant VALGPM value. Note that in the later versions of the model, VALGPM is allowed to vary with the zero point.

The zero point used in this experiment is 20 mpg, while the baseline VALGPM value corresponds to 18.7 mpg. The net price and fuel economy responses are small. Net prices generally change by less that 1% in any year. Fuel economies are more responsive with the changes ranging from 0 to 5% or up to 1.1 mpg. The HSRI staff also examined the impact of changing the zero point to 30 mpg. This change also produced a relatively small impact on the Industry/Policy Block's outputs.

8.9 Summary

The Policy Block's forecasts of net price and fuel economies vary in their responsiveness to changes in the policy variables and model assumptions. The responses are generally small relative to the percentage changes in the policy variables. New-car fuel economies are not very sensitive to gasoline prices. Increasing the price of gasoline by 100% yielded increases in fuel economies of new cars that averaged under 5% per year, under either the Standard/Penalty or Excise Tax/Rebate option. As for the technological cost functions, 10% higher parameters produced varied responses in the automobile price and fuel economy forecasts.

Prices responded the most under the Standard/Penalty option and were higher by up to 4.1%. The higher parameters also resulted in generally lower fuel economies.

Substantial changes in the lifetime mileage and generalized price scale factor (VALGPM) assumptions produced relatively small responses in the forecasts of automobile prices and fuel economies. Increasing the lifetime mileage assumption by fifty percent changes the forecast prices by, at most, three percent in any given year. The average annual price responses are about one percent under either of the policy options. The fuel economies are higher by an annual average of two to three percent. Changing the scale factor, VALGPM, to equal the zero point in the Excise Tax option produced small (less than 1%) changes in price and only slightly larger fuel economy responses (less than 5%).

The HSRI staff also examined changes in the policy variables. Increasing the fuel economy standard by 25% percent over the base case increased prices by an average 12.2% in any given year. Fuel economies also increased, averaging 8.9%. Doubling the base case penalty caused fuel economies to increase by 1% to 2%. This experiment also displayed some of the tradeoffs built into the Industry/Policy Block: small-car prices dropped at an increasing rate over time, medium-car prices stayed relatively stable, and large-car prices increased at an increasing rate, rising to 8% higher than the base case in the final year of the simulation. Doubling the base case excise tax/rebate schedule produced price responses similar to the doubled penalty except that medium-car prices were sharply higher in comparison. With a doubled excise tax/rebate schedule, fuel economies are generally higher, but by rarely more than 10%, than in the base case.

9.0 SUMMARY AND CONCLUSIONS

9.1 Summary of Findings

1. The Faucett model is a relatively small model with six econometric equations. The model's objective is to forecast the impacts of alternative federal fuel economy and fuel price policies on gasoline consumption, vehicle miles traveled (VMT), new-car sales and prices, size-class market shares, automobile stock, and fuel economy. The model can simulate the following policies: an Excise Tax/Rebate policy where new automobiles are assessed taxes or subsidies based on fuel economies; Standard/Penalty policy where each automakers' corporate average fuel economy must attain a government determined standard or incur a penalty; concurrent use of the above two policies; and gasoline price policies. The Faucett model was a pioneering attempt to model manufacturers' responses to government policy alternatives given technological fuel-economy cost tradeoffs by simulating the changing size and composition of the U.S. automobile stock. The model is composed of an Automobile Industry/Policy Block and an Automobile Demand Block.

2. The Industry/Policy Block represents the supply side of the automobile market. Car prices and fuel economy ratings are forecast based on the policy choices and rather tenuous projections of technological costs using a cost-minimizing algorithm. This algorithm is based on the assumption that the automakers minimize the sum of new-car price and lifetime gasoline operating costs and that all policy-induced costs are passed on to the consumers. The supply side response embodied in the algorithm allows for tradeoffs among direct policy costs, technological costs of increasing fuel economy and the savings to the consumer resulting from higher vehicle fuel economies. The supply side representation oversimplifies the industry's behavioral characteristics. In addition, this algorithm may yield different prices and fuel economies than would a profit-maximizing model. An unnecessarily

complex and imprecise process is used to find the policy add-on costs resulting from the standard/penalty policy option. The relative positions of the manufacturers are assumed to be constant over time. Car prices and fuel economy ratings enter the Demand Block as inputs, thereby linking the two blocks.

3. The Demand Block contains all six econometric equations. Using a conventional multiple linear regression package, the HSRI staff successfully reproduced the numerical results of all of the econometric equations except that for the automobile ownership per household by income. This equation, used in forecasting target automobile stock, constitutes the cornerstone of the model's stock adjustment process. The inability to reproduce the ownership equation is therefore particularly disconcerting. The statistical evidence does not support the inclusion of the stock adjustment variable in the new-car sales equation. This casts serious doubts upon the particular stock adjustment process employed in the model.

Serious flaws were discovered in three equations. The coefficients of the scrappage equation differ significantly, depending upon the inclusion of the final observation in the sample period, and are considered to be unstable. The target stock equation is clearly incomplete, since it depends only on household ownership and neglects corporate and government fleets. The market shares equation is based upon restrictive and at least partially incorrect assumptions and is used with a questionable normalization procedure.

4. The execution of the model in the computer program fails to live up to the design. As programmed, the model is entirely recursive. Some relationships might have been modeled more accurately by use of simultaneous equations. Incomplete recording of the model-building process inhibits efforts to understand the model. For instance, several variables are modified by constants without adequate justification. Although an elementary task in computer implementation of a model is verifying that the computer program accurately portrays the model, there is no evidence that this was done. As a result, there are inconsistencies between the model as it was estimated and the computer program that

implements the model.

5. Forecasting experiments over the sample (1963-1973) period reveal that a naive time trend outperforms the Faucett model in forecasting VMT, gasoline consumption, and large-car market share at the 0.05 significance level. The model's remaining forecasts are indistinguishable from those of a time trend at this significance level. The model's forecasts of size-class market shares have the highest %RMSEs, which range from 11.03 to 28.89. In addition, the model's forecasts of VMT and gasoline consumption are upward biased, and the forecasts of cars in use and medium- and large-car market shares accumulate error as the forecast horizon is lengthened. The magnitude of the gasoline consumption forecasts monotonically increases or decreases, apparently depending upon the level of gasoline prices, as the forecast horizon is lengthened. This suggests that the model may not be able to forecast turns in gasoline consumption.

6. A forecasting experiment over three postsample years exposed several questionable procedures that improve the model's short-run forecasts but have dubious value for long-run forecasting. One procedure adjusts the highly inaccurate new-car sales forecasts by a "DRI factor," thereby improving the models apparent forecasting accuracy. When the HSRI staff made several corrections to the model, the results for predictive accuracy over the sample period were mixed. However, in postsample forecasting, a version of the model corrected by the HSRI staff forecast new-car sales with dramatically improved accuracy. The model's postsample forecasts of sales, gasoline consumption, and VMT are indistinguishable from those of a naive time trend at the 0.05 level of significance. Without the DRI adjustment, the model's sales forecast is outperformed by a naive time trend at the 0.10 level of significance.

7. Comparison of within-sample and postsample forecasting performance provides some evidence, though not overwhelming, that a time trend performs less well in the later period than in the earlier period. The Faucett model's performance, however, seems to be generally the same for both periods, except for the gasoline consumption forecast, which has a significantly lower MSE in the later period. The reasons for

this result indicate that users of the model should be aware of the set of subfleet fuel economies present in the version of the model they are using. Furthermore, they should cautiously use the results of this postsample forecasting experiment as an indication of the model's future-year forecasting performance.

8. In addition to the statistical significance of the model's forecasts, there is also a question of the computational significance of the forecasts. Computational significance is limited by the number of significant digits in the data used to produce the forecasts. The number of significant digits in the gasoline prices used in the model, for example, was found to limit the number of significant digits in the sales, VMT, and gasoline consumption forecasts. The problem of computational significance is complicated by the impact of rounding on the estimated equations, so that computational significance cannot be determined by simple examination of the model.

9. Sensitivity analysis of the Demand Block indicates that changes in the values of the exogenous variables have a substantial impact on the forecast level of annual new-car sales in the short run, but minor impact in the long run. No matter what the policy on price and operating cost, the model predicts only a temporary impact on annual new-car sales. The impacts on the forecasts of the other variables tend to increase over time, which is reasonable. Some of the impact elasticities implied by the model have inappropriate signs. The incorrectly signed elasticities are small and can be attributed to the model's structure. These results give warning that the model's output must be cautiously interpreted. Sensitivity analysis of the market shares forecasts often produced anomalous results. Some of these anomalies were traced to the model authors' procedure for normalizing market shares and disappeared when a simpler procedure was employed.

10. The Policy Block's net price and fuel economy forecasts vary in sensitivity to the policy variables (gasoline price, fuel economy standards and penalties, and excise taxes and rebates). Large percentage changes in the policy variables produce relatively smaller percentage changes in price and fuel economy forecasts. Gasoline price is a particularly weak

determinant of fuel economy in the Policy Block. Net price and fuel economy are quite insensitive to the Policy Block's weakest assumptions (including the technological cost and lifetime miles traveled assumptions). However, relatively large changes in the assumed technological add-on cost curve can substantially alter the price and fuel economy forecasts.

9.2 Conclusions

The Jack Faucett Associates Automobile Sector Forecasting Model was designed for two major uses: forecasting and policy analysis. The HSRI staff does not recommend this model for either use, because of a lack of confidence in the basic structure of the model's econometric equations. The corrections suggested by the HSRI staff, although found to improve forecasting accuracy, are not sufficient to remedy these basic structural problems.

9.2.1 Forecasting.

- The model is a weak forecasting tool. The model is outperformed by a simple linear time trend even when predicting the sample data with which the model was estimated. Forecasts for some variables are biased and some accumulate errors as the forecasting horizon is lengthened.
- The model's postsample forecasts of sales, VMT, and gasoline consumption are indistinguishable from a naive time trend's forecasts at the 0.05 level of significance. Postsample forecasts of new-car sales without the DRI adjustment factor are an order of magnitude less accurate than forecasts generated by others (e.g., DRI). Simple corrections to the model can improve the accuracy of the sales forecasts. However, most of the forecasting error persists even after correction, most probably because of the fundamental problems with the Demand Block's key equations discussed in Section 4.0.
- There is evidence to suggest that the model may, in part, be based on knowledge of postsample years. If this is so, these postsample years cannot be appropriately used to test the model's

performance.

- There are serious problems with the market shares equation's specification, estimation, and use. The model's least accurate forecasts are those of market shares.

9.2.2 Policy Analysis.

- The model cannot reliably forecast the levels of corporate average fuel economy and, thus, should not be considered an adequate tool for analysis of the Standard/Penalty policy. The unreliability derives both from the inadequacies of the Industry/Policy Block and the inaccurate forecasts of market shares generated by the Demand Block.
- The model is a limited tool for analysis of gasoline tax or excise tax/rebate policies. The model often implies that there is essentially no relationship between gasoline or automobile prices and new-car sales or market shares, especially in the long run. Thus, the model is incapable of simulating any such long-run impacts of policies that affect the automobile sector via prices.
- The policy analyst who chooses to use the Faucett model without a full understanding of the model and the data on which it is based might easily fall into serious errors of analysis. Potential for such error lies in the input of data, interpretation of the computational and statistical significance of the data, adjustments to the model's forecasts before printout, and the use of the postsample period to assess the model's performance.
- If policy analysts use the Faucett model, they should correct the model in the ways suggested by the HSRI staff and explicitly account for the numerous problems noted by the HSRI staff, prior to any policy recommendation.

APPENDIX A

DEFINITIONS OF STATISTICS

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This appendix contains brief descriptions of the statistics presented in this report. The reader who is interested in more detailed descriptions should consult a good econometrics or statistics text. Three standard references are Kmenta (1971), Dhrymes (1970), and Theil (1971).

Most of the statistics used relate to determining why the variations in the dependent variable occur. These variations can be decomposed into unexplained variations and explained variations. The explained variations are those resulting from changes in the explanatory variables. The unexplained variations are nonsystematic variations and are assumed to be random in nature when the equation is properly specified.

The following statistics are used:

Adjusted R-squared ($\bar{R}^2$): This statistic, also known as the corrected coefficient of determination, is a measure of the goodness of fit of the estimated equation. The nonadjusted R^2 is the proportion of the variation in the dependent variable "explained" by the independent variables. The adjusted R-squared modifies R^2 by taking into consideration the number of estimated coefficients and the number of observations used in the estimation. $\bar{R}^2$ is calculated as follows:

$$\bar{R}^2 = R^2 - \left(\frac{K - 1}{n - K}\right) (1 - R^2)$$

where K is the number of estimated coefficients and n is the sample size. $\bar{R}^2$ has a maximum value of 1.0, and the closer to one the better the fit; unlike R^2, $\bar{R}^2$ may have a negative value.

F-Statistic (F): This statistic indicates the statistical significance of the regression coefficients as a group. In other words, it is another measure of the explanatory power of the equation. The F-statistic is related to, and can be expressed in terms of, R-squared.

Standard Error of Regression (SER): SER squared is an estimate of the variance of the disturbance term, i.e., the unexplained variations in the dependent variable.

Degrees of Freedom (DF): The degrees of freedom are calculated as the number of observations used in the estimation, minus the number of estimated coefficients. For estimation purposes, the number of observations must be larger than the number of coefficients. For technical reasons, the greater the number of degrees of freedom, the more reliable are the estimated coefficients.

Durbin-Watson Statistic (DW): This statistic tests for the presence of serial correlation (also referred to as auto correlation or auto-regressive disturbances). Serial correlation in a time series regression means that the unexplained variations in the dependent variable (i.e., regression disturbances) are correlated with one another. With serial correlation the coefficients estimated by the ordinary least squares estimation technique are not efficient (minimum variance). Moreover, the associated estimates of the variances of the coefficients are biased so that the tests of significance are not reliable.

Mean Square Error (MSE): The sum of the squared errors of a forecast, divided by the number of observations forecast. Root Mean Square Error (RMSE) is the square root of MSE.

SIML R-SQ Statistic: The SIML R-SQ is a measure of the predictive accuracy of the equation as solved in the model simulation, and is calculated by

$$\text{SIML R-SQ} = 1 - \frac{\sum_{t=a}^{b} (s_t - h_t)^2}{\sum_{t=a}^{b} (h_t - \bar{h})^2}$$

where

a	=	starting year of simulation
b	=	ending year of simulation
s_t	=	simulated value in year t
h_t	=	actual historical value in year t
$\bar{h}$	=	average historical value

The formula presented above is similar to the one used to calculate the R^2 for the single-equation model. One difference between the SIML R-SQ and the single-equation R^2 is in the computation of the endogenous value, which in this case is the simulation value, s_t. In the single-equation model, the endogenous (predicted) variable is computed using the actual values of the predetermined variables for each year in the sample period. In the case of SIML R-SQ, the endogenous variable s_t, is based on different data. In this case one uses the same values for the exogeneous variables and values generated by the model rather than actual values for the lagged endogenous variables.

Over the forecasting interval (a to b), the SIML R-SQ statistic expresses the variation between the historical and simulated values as a fraction of the total variation in the historical values. When a single equation is estimated using OLS, it is guaranteed that the sum of the residuals equals zero and the sum of the product of the residuals and the explanatory variable also equals zero. The consequence of this is that total variation can be decomposed into two parts, "explained" variation and "unexplained" variation. When the simulation is performed this condition does not necessarily hold and it is possible for "explained" plus "unexplained" variation to be greater than "total" variation. Since the total variation of the simulated values from the actual values may exceed the total variation of the actual values from their mean, the SIML R-SQ, like $\bar{R}^2$ and unlike the R^2, may have a negative value. That is, $\Sigma(s_t - h_t)^2$ may be greater than $\Sigma(h_t - \bar{h})^2$.

The SIML R-SQ has the same interpretation for the multiequation model as the R^2 has for the single-equation model over the positive range. That is, positive SIML R-SQ values indicate the proportion of the variation of the endogenous variable that can be attributed to the predictive accuracy of the model. Negative values can be taken to indicate changes in the structure of the modeled system that are not explained by the model. That is, instability of the estimated coefficients is indicated.

APPENDIX B

CALCULATIONS RELATED TO SECTION 6.0

APPENDIX B
CALCULATIONS RELATED TO SECTION 6.0

Cars by Class and Vintage

Three basic assumptions were made by the HSRI staff in calculating the number of cars by size classes and by vintage existing as of December 31 of each year. First, the data on the subfleets by model year in each year as of July 1 had to be converted to December 31 values. Second, the shares by class of these model-year cars are assumed to remain the same throughout their operating life span, i.e., scrappage rates are equal for the three classes. Finally, the market shares of 1949 to 1962 model-year cars were assumed to be the same as the shares for the 1963 model-year cars.

The following three equations summarize the calculation process:

1) $F_t^M = F_{t-1/2}^M - (F_{t-1/2}^M \times \frac{SR^M}{2})$ for M=3 to 14 where 14 = fourteen-year-old or older cars

2) $F_t^1 = N_t$

3) $F_t^2 = AS_t - (\sum_{M=3}^{14} F_t^M) - F_t^1$

where

F_t^M = number of M year old cars as of December 31 in year t

$F_{t-1/2}^M$ = number of M year old cars as of July 1 in year t, as listed in Table 4-2

SR^M = scrappage rate for cars M years old, as listed in Table 4-1

AS_t = number of cars in use as of December 31 in year t, as listed in Table B-1

TABLE B-1

NEW CAR REGISTRATIONS

Year	New Cars Registered During Year	Cars in Use on Dec. 31
1963	7,556,717	61,903,289
1964	8,065,150	64,264,066
1965	9,313,912	66,704,456
1966	9,008,488	68,754,966
1967	8,357,421	70,886,144
1968	9,403,863	73,941,518
1969	9,527,283	76,007,817
1970	8,459,503	78,446,279
1971	9,963,558	81,351,808
1972	10,608,236	83,972,660
1973	11,477,559	88,256,540

Source: Automotive News, Almanac issue, 1975.

N_t = number of new-car sales in year t, as listed in Table B-1

These subfleets by model year as of December 31 in year t were further divided into classes as follows.

$$F_t^{C,M} = F_t^M \times SH_t^{C,M}$$

where

$F_t^{C,M}$ = number of M year old cars in Class C as of December 31 in year t

$SH_t^{C,M}$ = market share of class C for M year old cars in year t

The number of cars by size class and by vintage existing as of December 31 of each year (1962 to 1973) is presented in Table B-2.

Net Prices of Cars by Class

The net prices of cars by class were calculated by subtracting the operating cost from the generalized prices by class, and are presented in Table B-3.

$$NP_t^C = X_t^C - (52{,}853 \times G_t/FE_t^C)$$

where

NP_t^C = net price of car by class in year t in 1967 dollars

X_t^C = generalized price by class in year t in 1967 dollars, as listed in Table 4-12

G_t = fuel price in year t in 1967 dollars, as listed in Table B-4

FE_t^C = fuel economy rating by class in year t, as listed in Table 4-12

Modified Net Prices of Cars by Class

The alteration of net prices of cars by class is as follows:

$$MNP_t^C = NP_t^C - [(\sum_C SH_t^C \times X_t^C) - (JA_t)]$$

where

MNP_t^C = modified net price of cars of class C in period t in 1967 dollars

NP_t^C = net price of cars of class C in period t in 1967 dollars, as listed in Table B-3

JA_t = JFA-calculated average generalized price used in regression in 1967 dollars, as listed in Table 4-12

SH_t^C = market share of new cars in class C in year t, as calculated from Table 4-12

X_t^C = generalized price of cars of class C in year t in 1967 dollars, as listed in Table 4-12

TABLE B-2

SMALL SIZE CARS BY VINTAGE IN YEARS 1962-1973
(in thousands)

CARS BY VINTAGE \ YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	2050	2232	2452	2312	2116	1643	1642	1840	2247	3022	3422	3427
2	1427	1723	1956	2755	1935	1680	1208	1098	1547	1650	1929	2292
3	1825	1606	1953	2155	2373	2215	2070	1579	1535	1787	2345	2636
4	1699	1819	1527	1947	2148	2340	2207	2056	1541	1529	1753	2276
5	1247	1673	1794	1575	1920	2100	2307	2176	2985	1513	1496	1698
6	1695	1209	1622	1742	1533	1858	2049	2250	2075	1919	1449	1423
7	1608	1598	1138	1549	1650	1440	1772	1956	2098	1893	1807	1358
8	1698	1474	1437	1021	1388	1479	1306	1627	1758	1919	1787	1635
9	1019	1496	1275	1232	829	1151	1256	1113	1377	1531	1658	1536
10	1038	848	1243	1050	955	622	883	983	862	1127	1243	1347
11	515	824	677	990	811	704	505	630	713	649	859	950
12	507	396	625	513	742	570	503	300	428	514	461	624
13	539	430	295	457	371	524	404	357	200	297	355	318
14	656	956	1061	1026	1027	1001	1099	1081	1036	923	887	897

TABLE B-2 (continued)

MEDIUM SIZE CARS BY VINTAGE IN YEARS 1962-1973
(in thousands)

CARS BY VINTAGE \ YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	1368	1490	1341	1898	2101	2390	2585	2072	1898	1459	816	1167
2	952	1150	1305	1507	1588	1668	1757	1729	1742	1391	931	666
3	1218	1071	1303	1438	1298	1819	2055	2297	2417	2013	1980	1272
4	1133	1214	1019	1299	1433	1280	1812	2041	2241	2407	1974	1922
5	835	1116	1197	1051	1282	1401	1262	1787	1971	2201	2356	1912
6	1131	807	1082	1163	1023	1240	1367	1231	1703	1905	2108	2240
7	1073	1066	759	1033	1101	961	1182	1305	1148	1615	1744	1975
8	1133	984	959	681	926	987	871	1086	1173	1050	1967	1632
9	680	999	851	822	553	768	838	742	919	1022	907	1261
10	692	566	830	700	637	415	589	656	575	752	829	737
11	344	550	452	661	541	470	337	420	476	433	873	634
12	378	265	417	342	496	380	336	200	285	343	308	417
13	360	287	197	305	248	350	270	238	139	198	237	212
14	464	638	708	685	685	668	733	721	691	616	592	598

TABLE B-2 (continued)

LARGE SIZE CARS BY VINTAGE IN YEARS 1962-1973
(in thousands)

CARS BY VINTAGE \ YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	3522	3835	4772	5104	4792	4324	5177	5615	4315	5483	6370	6883
2	2451	2960	3361	4801	4271	3804	3179	3463	4722	3168	3499	5197
3	3135	2759	3355	3702	4134	4890	4687	4156	4840	5455	4503	4783
4	2918	3125	2623	3345	3690	4077	4873	4655	4055	4820	5349	4371
5	2149	2874	3082	2706	3301	3608	4020	4804	4496	3981	4718	5182
6	2912	2078	2786	2993	2633	3192	3520	3920	4580	4345	3813	4485
7	2763	2746	1955	2660	2834	2474	3044	3361	3656	4394	4091	3573
8	2917	2533	2469	1753	2384	2541	2243	2796	3020	3344	3945	3702
9	1751	2573	2190	2117	1424	1978	2158	1911	2366	2630	2890	3391
10	1783	1957	2136	1803	1641	1069	1516	1688	1480	1936	2135	2347
11	885	1415	1163	1701	1394	1209	867	1083	1226	1115	1976	1633
12	973	681	1073	882	1276	979	864	516	735	883	792	1072
13	926	739	508	786	638	900	695	613	344	510	609	547
14	1196	1643	1822	1763	1765	1720	1888	1857	1779	1586	1525	1540

Calculated using data listed in Tables 4-1, 4-2, 4-12, and B-1.

TABLE B-3

NET PRICES OF CARS BY CLASS
(in 1967 dollars)

YEAR	SMALL	MEDIUM	LARGE
1963	2197.5	2894.6	3721.5
1964	2347.8	2883.3	3672.4
1965	2376.6	2765.3	3865.0
1966	2361.7	2840.4	3831.5
1967	2409.9	2824.1	4022.5
1968	2134.7	2713.8	3735.4
1969	1945.4	2769.4	4032.7
1970	1873.8	2601.4	3791.0
1971	1721.4	2486.1	3854.5
1972	1678.6	2273.4	3409.8
1973	1778.5	2249.3	3352.2

Calculated using data listed in Tables 4-12 and B-4.

TABLE B-4

HISTORICAL GASOLINE PRICES ($1967)

1963	.3320
1964	.3263
1965	.3330
1966	.3310
1967	.3316
1968	.3327
1969	.3162
1970	.3011
1971	.2906
1972	.2848
1973	.2942

Data Sources:

Gasoline Prices: Jack Faucett Associates

Price Indexes: U.S. Bureau of the Census 1978
Statistical Abstract of the United States

APPENDIX C

TABLES FOR SECTION 6.0

TABLE C-1
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
NEW CAR SALES

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	7556140.000	8852415.000	-1296275.000	17.155
1964	8064919.000	8731029.000	-666110.000	8.259
1965	9313223.000	8031540.000	1281683.000	13.762
1966	9009486.000	8155028.000	854458.000	9.484
1967	8357954.000	8104427.000	253527.000	3.033
1968	9403727.000	9338275.000	65452.000	0.696
1969	9527962.000	8979385.000	548577.000	5.758
1970	8458629.000	9742072.000	-1283443.000	15.173
1971	9963226.000	10039273.000	-76047.000	0.763
1972	10607180.000	10821622.000	-214442.000	2.022
1973	11476250.000	10336898.000	1139352.000	9.928

TABLE C-2
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
SCRAPPAGE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	5319286.000	6059964.000	-740678.000	13.924
1964	5704373.000	6172259.000	-467886.000	8.202
1965	6173512.000	6267486.000	-93974.000	1.522
1966	6957988.000	6330893.000	627095.000	9.013
1967	6226243.000	6118695.000	107548.000	1.727
1968	6348488.000	6276709.000	71779.000	1.131
1969	7460984.000	6350000.000	1110984.000	14.891
1970	6021041.000	6300898.000	-279857.000	4.648
1971	7058029.000	6510634.000	547395.000	7.756
1972	7987384.000	7166762.000	820622.000	10.274
1973	7193679.000	7742069.000	-548390.000	7.623

TABLE C-3
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
VEHICLE MILES TRAVELED

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	645.400	675.927	-30.527	4.730
1964	677.600	714.780	-37.179	5.487
1965	706.400	746.909	-40.509	5.735
1966	744.800	776.799	-31.999	4.296
1967	766.500	802.740	-36.240	4.728
1968	805.700	838.885	-33.185	4.119
1969	849.600	866.597	-16.997	2.001
1970	890.800	906.690	-15.890	1.784
1971	939.100	946.285	-7.185	0.765
1972	986.400	989.098	-2.698	0.273
1973	1016.900	1031.905	-15.005	1.476

TABLE C-4
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
GASOLINE CONSUMPTION

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	45246.000	44802.594	443.406	0.980
1964	47567.000	48780.051	-1213.051	2.550
1965	50206.000	52372.410	-2166.410	4.315
1966	53220.000	56195.316	-2975.316	5.591
1967	55007.000	59201.320	-4194.320	7.625
1968	58413.000	63300.348	-4887.348	8.367
1969	62325.000	66490.438	-4165.438	6.683
1970	65649.000	70416.563	-4767.563	7.262
1971	69213.000	73921.313	-4708.313	6.803
1972	73121.000	77858.000	-4737.000	6.478
1973	77619.000	81775.313	-4156.313	5.355

TABLE C-5
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
TOTAL CARS IN USE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	61903296.000	62417168.000	-513872.000	0.830
1964	64264064.000	64975920.000	-711856.000	1.108
1965	66704464.000	66739984.000	-35520.000	0.053
1966	68754960.000	68564096.000	190864.000	0.278
1967	70886144.000	70549808.000	336336.000	0.474
1968	73941520.000	73611328.000	330192.000	0.447
1969	76007824.000	76240672.000	-232848.000	0.306
1970	78446272.000	79681776.000	-1235504.000	1.575
1971	81351808.000	83210368.000	-1858560.000	2.285
1972	83972656.000	86865232.000	-2892576.000	3.445
1973	88256544.000	89459968.000	-1203424.000	1.364

TABLE C-6
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
SMALL SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.295	0.266	0.029	9.935
1964	0.304	0.222	0.082	26.939
1965	0.248	0.190	0.058	23.272
1966	0.235	0.158	0.077	32.665
1967	0.197	0.178	0.019	9.575
1968	0.175	0.203	-0.028	16.285
1969	0.193	0.249	-0.056	28.917
1970	0.266	0.269	-0.004	1.414
1971	0.303	0.313	-0.009	3.086
1972	0.323	0.320	0.003	0.806
1973	0.296	0.311	-0.015	5.185

TABLE C-7
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
MEDIUM SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.197	0.175	0.023	11.452
1964	0.166	0.196	-0.030	17.923
1965	0.204	0.228	-0.024	11.686
1966	0.233	0.258	-0.024	10.465
1967	0.286	0.231	0.055	19.275
1968	0.275	0.209	0.066	23.984
1969	0.217	0.166	0.051	23.562
1970	0.224	0.163	0.061	27.256
1971	0.146	0.136	0.010	6.959
1972	0.077	0.165	-0.088	114.157
1973	0.102	0.203	-0.101	99.154

TABLE C-8
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
LARGE SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.507	0.559	-0.052	10.231
1964	0.530	0.582	-0.052	9.834
1965	0.548	0.582	-0.034	6.194
1966	0.532	0.584	-0.052	9.838
1967	0.517	0.591	-0.074	14.293
1968	0.550	0.588	-0.037	6.812
1969	0.589	0.585	0.005	0.779
1970	0.510	0.567	-0.057	11.249
1971	0.550	0.551	-0.001	0.150
1972	0.600	0.515	0.085	14.186
1973	0.602	0.486	0.117	19.361

TABLE C-9
FORECASTING EXPERIMENT
WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK
NEW CAR SALES

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	7556140.000	7083095.000	473045.000	6.260
1964	8064919.000	7675111.000	389808.000	4.833
1965	9313223.000	8449903.000	863320.000	9.270
1966	9009486.000	8797332.000	212154.000	2.355
1967	8357954.000	9017223.000	-659269.000	7.888
1968	9403727.000	9618250.000	-214523.000	2.281
1969	9527962.000	10491298.000	-963336.000	10.111
1970	8458629.000	9584086.000	-1125457.000	13.305
1971	9963226.000	9571136.000	392090.000	3.935
1972	10607180.000	9615397.000	991783.000	9.350
1973	11476250.000	10604007.000	872243.000	7.600

TABLE C-10
FORECASTING EXPERIMENT
WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK
SCRAPPAGE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	5319286.000	5846594.000	-527308.000	9.913
1964	5704373.000	6051617.000	-347244.000	6.087
1965	6173512.000	6333718.000	-160206.000	2.595
1966	6957988.000	6407123.000	550865.000	7.917
1967	6226243.000	6185403.000	40840.000	0.656
1968	6348488.000	6231129.000	117359.000	1.849
1969	7460984.000	6356587.000	1104397.000	14.802
1970	6021041.000	6108461.000	-87420.000	1.452
1971	7058029.000	6249282.000	808747.000	11.459
1972	7987384.000	6843973.000	1143411.000	14.315
1973	7193679.000	7544752.000	-351073.000	4.880

TABLE C-11
FORECASTING EXPERIMENT
WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK
VEHICLE MILES TRAVELED

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	645.400	658.699	-13.300	2.061
1964	677.600	688.863	-11.262	1.662
1965	706.400	719.881	-13.481	1.908
1966	744.800	751.437	-6.637	0.891
1967	766.500	779.847	-13.347	1.741
1968	805.700	814.522	-8.823	1.095
1969	849.600	847.063	2.537	0.299
1970	890.800	891.668	-0.868	0.097
1971	939.100	931.024	8.076	0.860
1972	986.400	971.803	14.596	1.480
1973	1016.900	1015.805	1.095	0.108

TABLE C-12
FORECASTING EXPERIMENT
WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK
GASOLINE CONSUMPTION

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	45246.000	43433.301	1812.699	4.006
1964	47567.000	46906.723	660.277	1.388
1965	50206.000	50651.215	-445.215	0.887
1966	53220.000	54726.551	-1506.551	2.831
1967	55007.000	57929.176	-2922.176	5.312
1968	58413.000	61847.047	-3434.047	5.879
1969	62325.000	65268.801	-2943.801	4.723
1970	65649.000	69360.250	-3711.250	5.653
1971	69213.000	72726.563	-3513.563	5.076
1972	73121.000	76432.813	-3311.813	4.529
1973	77619.000	80355.875	-2736.875	3.526

TABLE C-13

FORECASTING EXPERIMENT

WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK

TOTAL CARS IN USE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	61903296.000	60861232.000	1042064.000	1.683
1964	64264064.000	62484688.000	1779376.000	2.769
1965	66704464.000	64600880.000	2103584.000	3.154
1966	68754960.000	66991024.000	1763936.000	2.566
1967	70886144.000	69822816.000	1063328.000	1.500
1968	73941520.000	73209968.000	731552.000	0.989
1969	76007824.000	77344624.000	-1336800.000	1.759
1970	78446272.000	80820192.000	-2373920.000	3.026
1971	81351808.000	84142016.000	-2790208.000	3.430
1972	83972656.000	86913360.000	-2940704.000	3.502
1973	88256544.000	89972576.000	-1716032.000	1.944

TABLE C-14

FORECASTING EXPERIMENT

WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK

SMALL SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.295	0.228	0.068	22.976
1964	0.304	0.177	0.127	41.685
1965	0.248	0.165	0.083	33.541
1966	0.235	0.148	0.087	37.005
1967	0.197	0.180	0.016	8.197
1968	0.175	0.206	-0.031	17.799
1969	0.193	0.274	-0.081	42.075
1970	0.266	0.288	-0.022	8.423
1971	0.303	0.325	-0.022	7.172
1972	0.323	0.320	0.002	0.713
1973	0.296	0.318	-0.022	7.586

TABLE C-15

FORECASTING EXPERIMENT

WITH CORRECTED (HSRI) VERSION OF THE DEMAND BLOCK

MEDIUM SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.197	0.177	0.020	10.259
1964	0.166	0.191	-0.025	15.029
1965	0.204	0.218	-0.014	7.036
1966	0.233	0.248	-0.015	6.490
1967	0.286	0.226	0.060	21.041
1968	0.275	0.207	0.068	24.858
1969	0.217	0.162	0.055	25.361
1970	0.224	0.162	0.062	27.795
1971	0.146	0.136	0.010	7.048
1972	0.077	0.166	-0.089	116.310
1973	0.102	0.203	-0.101	98.905

TABLE C-16
FORECASTING EXPERIMENT
WITH CORRECTED(HSRI) VERSION OF THE DEMAND BLOCK
LARGE SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.507	0.596	-0.088	17.358
1964	0.530	0.631	-0.102	19.205
1965	0.548	0.617	-0.069	12.575
1966	0.532	0.604	-0.072	13.497
1967	0.517	0.594	-0.076	14.746
1968	0.550	0.588	-0.037	6.768
1969	0.589	0.563	0.026	4.426
1970	0.510	0.550	-0.040	7.836
1971	0.550	0.539	0.011	2.078
1972	0.600	0.513	0.087	14.512
1973	0.602	0.479	0.123	20.499

APPENDIX D

THE NORMALIZATION PROCEDURE OF MARKET SHARES

APPENDIX D
THE NORMALIZATION PROCEDURE OF MARKET SHARES

D.1 An Evaluation of the Market Shares Normalization Procedure

This appendix examines the effect of JFA's large-car-share-weighted normalization procedure (henceforth called JFA normalization), by comparing it with an alternative normalization procedure. As mentioned in Section 4.4, the shares of the classes as predicted by the market shares equation must be normalized to sum to one. JFA used a procedure that places more emphasis on the large-car share as predicted by the market shares equation because, according to JFA, it is relatively price inelastic and therefore less subject to change. The other shares are determined after the normalized large-car share has been established.

The HSRI staff tested the following alternative normalization procedure:

$$SH_t^{C*} = \frac{SH_t^C}{\sum_{C=1}^{3} SH_t^C}$$

where

SH_t^{C*} = market share of class C at time t after normalization

SH_t^C = market share of class C at time t as estimated by the market share equation (before normalization)

This will be referred to as simple normalization.

Table D-1 contains the error statistics generated from the model simulation with the two types of normalization. There is little difference between the two sets of results. Tables D-2 to D-9 contain detailed results.

TABLE D-1

ERROR STATISTICS FOR THE WITHIN-SAMPLE PERIOD (1963-73): DYNAMIC SIMULATION OF ORIGINAL MODEL USING JFA AND SIMPLE NORMALIZATION PROCEDURES

	MEAN ACTUAL	RMSE		%RMSE		SIML R-SQ	
Variable	JFA, Simple	JFA	Simple	JFA	Simple	JFA	Simple
Sales	9,249,000	845,000	923,800	9.141	9.988	.4027	.2870
Scrappage	6,586,000	585,600	574,600	8.892	8.722	.4212	.4431
VMT (in billions)	820.8	27.33	34.41	3.33	4.192	.9483	.9181
Gas Consumption (in millions)	59,780	3,798	3,018	6.353	5.05	.8675	.9125
Cars In Use	74,040,000	1,202,000	1,935,000	1.623	2.613	.9777	.9422
Small Car Market Share	.2576	.04412	.04619	17.13	17.93	.2007	.1240
Medium Car Market Share	.1935	.05590	.05708	28.89	29.50	.2064	.1724
Large Car Market Share	.5489	.06055	.06239	11.03	11.37	-2.359	-2.565

D.2 Sensitivity Analysis of the Normalization Procedures

Most of the discussion of the sensitivity of the model in Section 7.0 is based on the JFA normalization procedure. When some of the experiments are repeated using simple normalization, the HSRI staff finds that the model is altered significantly.

The following multiplier experiments were performed:

1. 10% higher small-car net price
2. 10% higher large-car net price
3. 10% higher net prices of all cars
4. 100% higher gasoline prices

Detailed results are in Tables D-10 to D-40.

1. Ten percent higher small-car net prices (Tables D-10 to D-17):

   - Under simple normalization, the medium and large-car shares are more responsive than under JFA's normalization procedure.

2. Ten percent higher large-car net prices (Tables D-18 to D-25):

   - The large-car share is more inelastic under simple normalization than under JFA normalization. This is contrary to the HSRI staff's expectations since JFA selected their normalization procedure based on an inelastic large-car share. The price elasticity of large-car share under the simple version in the last year, 1973, is -0.26 while in the JFA version it is -0.45. However, the absolute size of the large-car share in the simple version is relatively larger in only the last 2 years of the simulation. The difference is as much as 4.7 percentage points.

3. Ten percent higher net prices for all cars (Tables D-26 to D-33):

   - Changing the normalization procedure changes the directions of the market shares' responses to the price increase. In the 11th year, 1973, under JFA normalization: the small-car share decreases by 11%, the medium-car share decreases by roughly 6%, and the large-car share increases by 9%. Under simple normalization: the small-car share increases by 5%, the medium-car share increases by 5%, and the large-car share decreases by 5%.

   - Gasoline consumption is slightly more responsive to a change in car prices with the simple procedure than with the JFA procedure. This is in part due to the shift to smaller cars with the simple procedure.

- VMT is less car-price elastic with the simple procedure. In that procedure, the 11th year car-price elasticity of VMT is -0.09 and in the JFA, -0.23.

4. One hundred percent higher gasoline prices (Tables D-34 to D-40):

- Again, the market shares responses are substantially different and signs change. In the simple version: the small-car share increases by 26%, the medium-car share increases by 7%, and the large-car share decreases by 17% in the 11th year of the forecast. In the JFA version: small-car share decreases by 36%, medium-car share decreases by 34%, and large-car share increases by 37%.

- Gasoline consumption decreases relatively more with the simple procedure.

- VMT decreases by 11% in the simple version versus 18% in the JFA version.

- Cars in use decrease by 12% in the simple version versus 24% in the JFA version.

- New-car sales are higher and less elastic in the simple version than in the JFA version.

The effect of the normalization procedures on the model can be summarized briefly. The JFA normalization procedure assumes that the large-car share is unresponsive to costs relative to the other shares. Large increases in car prices or operating cost can increase the large-car share. When the prices of all cars increase, some people who would otherwise purchase small and medium cars drop out of the market, while large-car buyers are unaffected. However, VMT is more elastic in the JFA version. Thus, in times of car price and operating cost increases consumers demand large cars and do not trade down, but are willing to drive fewer miles as a tradeoff to operating more fuel-inefficient cars.

Using the simple normalization procedure, consumers respond differently. Consumers of large cars are willing to trade down and purchase smaller cars when costs and prices increase. Demand for VMT is more inelastic and demand for gasoline more elastic. Thus, consumers are willing to sacrifice the benefits of large cars for the benefits of driving more miles. Although VMT is relatively higher with the simple procedure, gasoline consumption is generally less.

The multiplier experiments show that the type of normalization has important implications for the model. Unfortunately, most users of the model are probably unaware of the implications of the normalization procedure, and even if aware, might be unable to change it to meet their needs.

TABLES D-2 TO D-9
FORECASTING EXPERIMENT
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
USING THE SIMPLE SIZE-CLASS MARKET SHARE
NORMALIZATION PROCEDURE

TABLE D-2
NEW CAR SALES

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	7556140.000	9192098.000	-1635958.000	21.651
1964	8064919.000	9052368.000	-987449.000	12.244
1965	9313223.000	8295878.000	1017345.000	10.924
1966	9009486.000	8408353.000	601133.000	6.672
1967	8357954.000	8406754.000	-48800.000	0.584
1968	9403727.000	9595207.000	-191480.000	2.036
1969	9527962.000	9172036.000	355926.000	3.736
1970	8458629.000	9586930.000	-1128301.000	13.339
1971	9963226.000	9761636.000	201590.000	2.023
1972	10607180.000	10086933.000	520247.000	4.905
1973	11476250.000	9866894.000	1609356.000	14.023

TABLE D-3
SCRAPPAGE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	5319286.000	6059965.000	-740679.000	13.924
1964	5704373.000	6172939.000	-468566.000	8.214
1965	6173512.000	6269994.000	-96482.000	1.563
1966	6957988.000	6336727.000	621261.000	8.929
1967	6226243.000	6130706.000	95537.000	1.534
1968	6348488.000	6299147.000	49341.000	0.777
1969	7460984.000	6389761.000	1071223.000	14.358
1970	6021041.000	6367771.000	-346730.000	5.759
1971	7058029.000	6613601.000	444428.000	6.297
1972	7987384.000	7313076.000	674308.000	8.442
1973	7193679.000	7925122.000	-731443.000	10.168

TABLE D-4
VEHICLE MILES TRAVELED

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	645.400	678.190	-32.790	5.081
1964	677.600	719.266	-41.666	6.149
1965	706.400	753.272	-46.872	6.635
1966	744.800	784.939	-40.139	5.389
1967	766.500	812.956	-46.456	6.061
1968	805.700	850.838	-45.138	5.602
1969	849.600	879.742	-30.142	3.548
1970	890.800	918.566	-27.766	3.117
1971	939.100	955.800	-16.700	1.778
1972	986.400	992.935	-6.535	0.662
1973	1016.900	1031.323	-14.423	1.418

TABLE D-5
GASOLINE CONSUMPTION

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	45246.000	44805.762	440.238	0.973
1964	47567.000	48690.977	-1123.977	2.363
1965	50206.000	52153.516	-1947.516	3.879
1966	53220.000	55858.316	-2638.316	4.957
1967	55007.000	58729.348	-3722.348	6.767
1968	58413.000	62655.227	-4242.227	7.262
1969	62325.000	65687.375	-3362.375	5.395
1970	65649.000	69372.563	-3723.563	5.672
1971	69213.000	72680.438	-3467.438	5.010
1972	73121.000	76408.750	-3287.750	4.496
1973	77619.000	80474.875	-2855.875	3.679

TABLE D-6
TOTAL CARS IN USE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	61903296.000	62756848.000	-853552.000	1.379
1964	64264064.000	65636272.000	-1372208.000	2.135
1965	66704464.000	67662160.000	-957696.000	1.436
1966	68754960.000	69733728.000	-978768.000	1.424
1967	70886144.000	72009792.000	-1123648.000	1.585
1968	73941520.000	75305792.000	-1364272.000	1.845
1969	76007824.000	78087984.000	-2080160.000	2.737
1970	78446272.000	81307152.000	-2860880.000	3.647
1971	81351808.000	84455184.000	-3103376.000	3.815
1972	83972656.000	87228992.000	-3256336.000	3.878
1973	88256544.000	89170688.000	-914144.000	1.036

TABLE D-7
SMALL SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.295	0.302	-0.007	2.259
1964	0.304	0.272	0.032	10.396
1965	0.248	0.240	0.008	3.118
1966	0.235	0.207	0.028	11.998
1967	0.197	0.228	-0.032	16.155
1968	0.175	0.250	-0.076	43.457
1969	0.193	0.299	-0.106	54.867
1970	0.266	0.310	-0.044	16.692
1971	0.303	0.343	-0.040	13.062
1972	0.323	0.321	0.002	0.504
1973	0.296	0.289	0.007	2.264

TABLE D-8
MEDIUM SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.197	0.198	-0.001	0.537
1964	0.166	0.235	-0.069	41.463
1965	0.204	0.279	-0.076	37.065
1966	0.233	0.331	-0.098	42.012
1967	0.286	0.308	-0.022	7.599
1968	0.275	0.272	0.003	1.193
1969	0.217	0.209	0.008	3.778
1970	0.224	0.188	0.037	16.284
1971	0.146	0.147	-0.000	0.284
1972	0.077	0.159	-0.083	107.359
1973	0.102	0.186	-0.084	82.432

TABLE D-9
LARGE SALES SHARE

YEAR	ACTUAL	SIMULATION	ERROR	% DIFF
1963	0.507	0.500	0.008	1.524
1964	0.530	0.492	0.037	7.051
1965	0.548	0.480	0.068	12.372
1966	0.532	0.462	0.070	13.121
1967	0.517	0.464	0.053	10.339
1968	0.550	0.478	0.073	13.187
1969	0.589	0.492	0.098	16.582
1970	0.510	0.502	0.008	1.531
1971	0.550	0.510	0.040	7.275
1972	0.600	0.520	0.081	13.478
1973	0.602	0.525	0.077	12.866

TABLES D-10 TO D-40
MULTIPLIER EXPERIMENTS
WITH THE UNCORRECTED (JFA) VERSION OF THE DEMAND BLOCK
USING THE SIMPLE SIZE-CLASS MARKET SHARE
NORMALIZATION PROCEDURE

TABLE D-10
10% INCREASE IN SMALL CAR NET PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.198	0.237	0.039	19.770
1964	0.235	0.301	0.066	27.896
1965	0.279	0.362	0.083	29.748
1966	0.331	0.421	0.090	27.139
1967	0.308	0.405	0.098	31.722
1968	0.272	0.371	0.100	36.675
1969	0.209	0.301	0.092	43.961
1970	0.188	0.271	0.084	44.573
1971	0.147	0.214	0.067	45.773
1972	0.159	0.221	0.062	38.674
1973	0.186	0.252	0.065	35.041

TABLE D-11
10% INCREASE IN SMALL CAR NET PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.500	0.492	-0.008	1.611
1964	0.492	0.475	-0.017	3.533
1965	0.480	0.451	-0.029	6.002
1966	0.462	0.424	-0.038	8.323
1967	0.464	0.421	-0.043	9.292
1968	0.478	0.434	-0.044	9.121
1969	0.492	0.457	-0.035	7.065
1970	0.502	0.476	-0.026	5.242
1971	0.510	0.498	-0.013	2.450
1972	0.520	0.512	-0.007	1.407
1973	0.525	0.514	-0.010	1.964

TABLE D-12
10% INCREASE IN SMALL CAR NET PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.302	0.271	-0.031	10.304
1964	0.272	0.224	-0.048	17.706
1965	0.240	0.186	-0.054	22.571
1966	0.207	0.155	-0.051	24.871
1967	0.228	0.174	-0.055	23.872
1968	0.250	0.194	-0.056	22.369
1969	0.299	0.242	-0.057	19.150
1970	0.310	0.253	-0.057	18.510
1971	0.343	0.288	-0.055	15.951
1972	0.321	0.267	-0.054	16.935
1973	0.289	0.234	-0.055	19.013

TABLE D-13
10% INCREASE IN SMALL CAR NET PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	9192098.000	8886566.000	-305532.000	3.324
1964	9052368.000	8883390.000	-168978.000	1.867
1965	8295878.000	8321743.000	25865.000	0.312
1966	8408353.000	8484579.000	76226.000	0.907
1967	8406754.000	8408330.000	1576.000	0.019
1968	9595207.000	9538367.000	-56840.000	0.592
1969	9172036.000	9059901.000	-112135.000	1.223
1970	9586930.000	9482547.000	-104383.000	1.089
1971	9761636.000	9580783.000	-180853.000	1.853
1972	10086933.000	10078950.000	-7983.000	0.079
1973	9866894.000	9869976.000	3082.000	0.031

TABLE D-14
10% INCREASE IN SMALL CAR NET PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059965.000	6026514.000	-33451.000	0.552
1964	6172939.000	6144365.000	-28574.000	0.463
1965	6269994.000	6248007.000	-21987.000	0.351
1966	6336727.000	6320494.000	-16233.000	0.256
1967	6130706.000	6117070.000	-13636.000	0.222
1968	6299147.000	6288535.000	-10612.000	0.168
1969	6389761.000	6373623.000	-16138.000	0.253
1970	6367771.000	6337178.000	-30593.000	0.480
1971	6613601.000	6566175.000	-47426.000	0.717
1972	7313076.000	7250419.000	-62657.000	0.857
1973	7925122.000	7857694.000	-67428.000	0.851

TABLE D-15
10% INCREASE IN SMALL CAR NET PRICE
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62756848.000	62484768.000	-272080.000	0.434
1964	65636272.000	65223744.000	-412528.000	0.629
1965	67662160.000	67297520.000	-364640.000	0.539
1966	69733728.000	69461584.000	-272144.000	0.390
1967	72009792.000	71752816.000	-256976.000	0.357
1968	75305792.000	75002608.000	-303184.000	0.403
1969	78087984.000	77688816.000	-399168.000	0.511
1970	81307152.000	80834160.000	-472992.000	0.582
1971	84455184.000	83848816.000	-606368.000	0.718
1972	87228992.000	86677264.000	-551728.000	0.633
1973	89170688.000	88689504.000	-481184.000	0.540

TABLE D-16
10% INCREASE IN SMALL CAR NET PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	678.190	676.446	-1.744	0.257
1964	719.266	716.575	-2.690	0.374
1965	753.272	750.824	-2.448	0.325
1966	784.939	783.106	-1.832	0.233
1967	812.956	811.138	-1.817	0.224
1968	850.838	848.692	-2.146	0.252
1969	879.742	876.942	-2.801	0.318
1970	918.566	915.245	-3.321	0.362
1971	955.800	951.508	-4.292	0.449
1972	992.935	988.908	-4.027	0.406
1973	1031.323	1027.691	-3.631	0.352

TABLE D-17
10% INCREASE IN SMALL CAR NET PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44805.762	44724.813	-80.949	0.181
1964	48690.977	48621.965	-69.012	0.142
1965	52153.516	52172.086	18.570	0.036
1966	55858.316	55855.539	-2.777	0.005
1967	58729.348	58845.414	116.066	0.198
1968	62655.227	62782.199	126.973	0.203
1969	65687.375	65820.875	133.500	0.203
1970	69372.563	69540.875	168.313	0.243
1971	72680.438	72978.375	297.938	0.410
1972	76408.750	76830.875	422.125	0.552
1973	80474.875	80990.000	515.125	0.640

TABLE D-18
10% INCREASE IN LARGE CAR NET PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.500	0.495	-0.005	0.977
1964	0.492	0.484	-0.008	1.603
1965	0.480	0.470	-0.010	2.163
1966	0.462	0.450	-0.012	2.564
1967	0.464	0.451	-0.013	2.835
1968	0.478	0.464	-0.014	2.880
1969	0.492	0.478	-0.014	2.839
1970	0.502	0.488	-0.014	2.760
1971	0.510	0.497	-0.014	2.652
1972	0.520	0.506	-0.014	2.631
1973	0.525	0.511	-0.014	2.668

TABLE D-19
10% INCREASE IN LARGE CAR NET PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.302	0.303	0.001	0.385
1964	0.272	0.274	0.002	0.648
1965	0.240	0.242	0.002	[illegible].802
1966	0.207	0.208	0.002	0.782
1967	0.228	0.230	0.002	0.766
1968	0.250	0.253	0.002	0.895
1969	0.299	0.303	0.004	1.176
1970	0.310	0.315	0.005	1.512
1971	0.343	0.349	0.006	1.826
1972	0.321	0.328	0.007	2.162
1973	0.289	0.296	0.007	2.314

TABLE D-20
10% INCREASE IN LARGE CAR NET PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.198	0.202	0.004	1.877
1964	0.235	0.241	0.006	2.604
1965	0.279	0.288	0.008	3.028
1966	0.331	0.341	0.010	3.090
1967	0.308	0.319	0.011	3.705
1968	0.272	0.283	0.012	4.243
1969	0.209	0.220	0.010	4.988
1970	0.188	0.197	0.009	4.888
1971	0.147	0.154	0.007	4.951
1972	0.159	0.166	0.007	4.222
1973	0.186	0.194	0.007	3.924

TABLE D-21
10% INCREASE IN LARGE CAR NET PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	9192098.000	8578627.000	-613471.000	6.674
1964	9052368.000	8673512.000	-378856.000	4.185
1965	8295878.000	8124614.000	-171264.000	2.064
1966	8408353.000	8271978.000	-136375.000	1.622
1967	8406754.000	8271303.000	-135451.000	1.611
1968	9595207.000	9400566.000	-194641.000	2.029
1969	9172036.000	9022849.000	-149187.000	1.627
1970	9586930.000	9537449.000	-49481.000	0.516
1971	9761636.000	9709913.000	-51723.000	0.530
1972	10086933.000	10184887.000	97954.000	0.971
1973	9866894.000	9785316.000	-81578.000	0.827

TABLE D-22
10% INCREASE IN LARGE CAR NET PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059965.000	5999191.000	-60774.000	1.003
1964	6172939.000	6126249.000	-46690.000	0.756
1965	6269994.000	6231070.000	-38924.000	0.621
1966	6336727.000	6306901.000	-29826.000	0.471
1967	6130706.000	6100634.000	-30072.000	0.491
1968	6299147.000	6267539.000	-31608.000	0.502
1969	6389761.000	6331097.000	-58664.000	0.918
1970	6367771.000	6279546.000	-88225.000	1.385
1971	6613601.000	6475813.000	-137788.000	2.083
1972	7313076.000	7140062.000	-173014.000	2.366
1973	7925122.000	7724842.000	-200280.000	2.527

TABLE D-23
10% INCREASE IN LARGE CAR NET PRICE
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62756848.000	62204144.000	-552704.000	0.881
1964	65636272.000	64751376.000	-884896.000	1.348
1965	67662160.000	66644944.000	-1017216.000	1.503
1966	69733728.000	68609952.000	-1123776.000	1.612
1967	72009792.000	70780640.000	-1229152.000	1.707
1968	75305792.000	73913632.000	-1392160.000	1.849
1969	78087984.000	76605344.000	-1482640.000	1.899
1970	81307152.000	79863200.000	-1443952.000	1.776
1971	84455184.000	83097280.000	-1357904.000	1.608
1972	87228992.000	86142112.000	-1086880.000	1.246
1973	89170688.000	88202480.000	-968208.000	1.086

TABLE D-24
10% INCREASE IN LARGE CAR NET PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	678.190	674.788	-3.402	0.502
1964	719.266	713.791	-5.475	0.761
1965	753.272	746.973	-6.299	0.836
1966	784.939	777.973	-6.966	0.887
1967	812.956	805.327	-7.629	0.938
1968	850.838	842.189	-8.649	1.016
1969	879.742	870.532	-9.210	1.047
1970	918.566	909.611	-8.955	0.975
1971	955.800	947.405	-8.395	0.878
1972	992.935	986.277	-6.658	0.671
1973	1031.323	1025.453	-5.870	0.569

TABLE D-25
10% INCREASE IN LARGE CAR NET PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44805.762	44458.285	-347.477	0.776
1964	48690.977	48173.297	-517.680	1.063
1965	52153.516	51563.656	-589.859	1.131
1966	55858.316	55202.492	-655.824	1.174
1967	58729.348	58012.883	-716.465	1.220
1968	62655.227	61832.258	-822.969	1.313
1969	65687.375	64792.426	-894.949	1.362
1970	69372.563	68466.375	-906.188	1.306
1971	72680.438	71786.063	-894.375	1.231
1972	76408.750	75603.625	-805.125	1.054
1973	80474.875	79659.250	-815.625	1.014

TABLE D-26
10% INCREASE IN NET PRICE OF ALL CARS
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.302	0.308	0.005	1.815
1964	0.272	0.279	0.007	2.454
1965	0.240	0.246	0.006	2.389
1966	0.207	0.213	0.007	3.188
1967	0.228	0.234	0.006	2.608
1968	0.250	0.259	0.008	3.240
1969	0.299	0.312	0.013	4.359
1970	0.310	0.325	0.015	4.878
1971	0.343	0.360	0.018	5.109
1972	0.321	0.338	0.017	5.445
1973	0.289	0.305	0.015	5.342

TABLE D-27
10% INCREASE IN NET PRICE OF ALL CARS
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.198	0.203	0.005	2.677
1964	0.235	0.246	0.010	4.376
1965	0.279	0.294	0.015	5.377
1966	0.331	0.346	0.015	4.448
1967	0.308	0.324	0.017	5.427
1968	0.272	0.286	0.015	5.419
1969	0.209	0.219	0.010	4.600
1970	0.188	0.196	0.008	4.145
1971	0.147	0.152	0.005	3.696
1972	0.159	0.165	0.006	3.750
1973	0.186	0.195	0.009	4.715

TABLE D-28
10% INCREASE IN NET PRICE OF ALL CARS
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.500	0.489	-0.011	2.158
1964	0.492	0.475	-0.017	3.449
1965	0.480	0.459	-0.021	4.325
1966	0.462	0.441	-0.021	4.613
1967	0.464	0.441	-0.023	4.884
1968	0.478	0.455	-0.023	4.778
1969	0.492	0.469	-0.023	4.609
1970	0.502	0.479	-0.023	4.559
1971	0.510	0.487	-0.023	4.497
1972	0.520	0.496	-0.023	4.515
1973	0.525	0.500	-0.024	4.618

TABLE D-29
10% INCREASE IN NET PRICE OF ALL CARS
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44805.762	44240.266	-565.496	1.262
1964	48690.977	47809.887	-881.090	1.810
1965	52153.516	51112.848	-1040.668	1.995
1966	55858.316	54653.723	-1204.594	2.157
1967	58729.348	57390.863	-1338.484	2.279
1968	62655.227	61126.094	-1529.133	2.441
1969	65687.375	64060.246	-1627.129	2.477
1970	69372.563	67740.313	-1632.250	2.353
1971	72680.438	71094.813	-1585.625	2.182
1972	76408.750	74964.063	-1444.688	1.891
1973	80474.875	79020.063	-1454.813	1.808

TABLE D-30
10% INCREASE IN NET PRICE OF ALL CARS
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	678.190	672.924	-5.266	0.776
1964	719.266	710.444	-8.822	1.227
1965	753.272	742.792	-10.480	1.391
1966	784.939	772.812	-12.127	1.545
1967	812.956	799.395	-13.561	1.668
1968	850.838	835.469	-15.369	1.806
1969	879.742	863.850	-15.892	1.806
1970	918.566	903.447	-15.118	1.646
1971	955.800	942.309	-13.491	1.412
1972	992.935	982.411	-10.523	1.060
1973	1031.323	1022.301	-9.022	0.875

TABLE D-31
10% INCREASE IN NET PRICE OF ALL CARS
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	9192098.000	8213454.000	-978644.000	10.647
1964	9052368.000	8384523.000	-667845.000	7.378
1965	8295878.000	7953696.000	-342182.000	4.125
1966	8408353.000	8087817.000	-320536.000	3.812
1967	8406754.000	8126848.000	-279906.000	3.330
1968	9595207.000	9255519.000	-339688.000	3.540
1969	9172036.000	8995482.000	-176554.000	1.925
1970	9586930.000	9561988.000	-24942.000	0.260
1971	9761636.000	9785808.000	24172.000	0.248
1972	10086933.000	10254142.000	167209.000	1.658
1973	9866894.000	9743212.000	-123682.000	1.254

TABLE D-32
10% INCREASE IN NET PRICE OF ALL CARS
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059965.000	5941193.000	-118772.000	1.960
1964	6172939.000	6078752.000	-94187.000	1.526
1965	6269994.000	6196746.000	-73248.000	1.168
1966	6336727.000	6281196.000	-55531.000	0.876
1967	6130706.000	6079869.000	-50837.000	0.829
1968	6299147.000	6248810.000	-50337.000	0.799
1969	6389761.000	6299725.000	-90036.000	1.409
1970	6367771.000	6224151.000	-143620.000	2.255
1971	6613601.000	6387007.000	-226594.000	3.426
1972	7313076.000	7018691.000	-294385.000	4.025
1973	7925122.000	7574859.000	-350263.000	4.420

TABLE D-33
10% INCREASE IN NET PRICE OF ALL CARS
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62756848.000	61896976.000	-859872.000	1.370
1964	65636272.000	64202688.000	-1433584.000	2.184
1965	67662160.000	65959648.000	-1702512.000	2.516
1966	69733728.000	67766272.000	-1967456.000	2.821
1967	72009792.000	69813232.000	-2196560.000	3.050
1968	75305792.000	72819856.000	-2485936.000	3.301
1969	78087984.000	75515616.000	-2572368.000	3.294
1970	81307152.000	78853392.000	-2453760.000	3.018
1971	84455184.000	82252192.000	-2202992.000	2.608
1972	87228992.000	85487632.000	-1741360.000	1.996
1973	89170688.000	87655888.000	-1514800.000	1.699

TABLE D-34
100% INCREASE IN FUEL PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.302	0.334	0.032	10.539
1964	0.272	0.313	0.040	14.826
1965	0.240	0.289	0.048	20.016
1966	0.207	0.234	0.027	13.028
1967	0.228	0.287	0.058	25.565
1968	0.250	0.311	0.061	24.187
1969	0.299	0.359	0.060	20.004
1970	0.310	0.369	0.059	18.921
1971	0.343	0.417	0.074	21.464
1972	0.321	0.394	0.073	22.714
1973	0.289	0.364	0.075	25.861

TABLE D-35
100% INCREASE IN FUEL PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.198	0.211	0.013	6.666
1964	0.235	0.257	0.022	9.263
1965	0.279	0.299	0.020	7.161
1966	0.331	0.377	0.046	13.822
1967	0.308	0.314	0.006	2.010
1968	0.272	0.280	0.008	2.959
1969	0.209	0.222	0.013	6.209
1970	0.188	0.205	0.017	9.224
1971	0.147	0.148	0.001	0.816
1972	0.159	0.167	0.008	4.999
1973	0.186	0.199	0.012	6.614

TABLE D-36
100% INCREASE IN FUEL PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.500	0.455	-0.045	9.013
1964	0.492	0.430	-0.062	12.629
1965	0.480	0.412	-0.068	14.188
1966	0.462	0.389	-0.073	15.733
1967	0.464	0.399	-0.065	13.918
1968	0.478	0.409	-0.069	14.358
1969	0.492	0.419	-0.073	14.810
1970	0.502	0.426	-0.076	15.123
1971	0.510	0.435	-0.075	14.659
1972	0.520	0.439	-0.081	15.566
1973	0.525	0.438	-0.087	16.599

TABLE D-37
100% INCREASE IN FUEL PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44805.762	40400.043	-4405.719	9.833
1964	48690.977	42964.633	-5726.344	11.761
1965	52153.516	45419.266	-6734.250	12.912
1966	55858.316	48118.133	-7740.184	13.857
1967	58729.348	50190.047	-8539.301	14.540
1968	62655.227	53053.941	-9601.285	15.324
1969	65687.375	55404.637	-10282.738	15.654
1970	69372.563	58636.633	-10735.930	15.476
1971	72680.438	61728.719	-10951.719	15.068
1972	76408.750	65323.352	-11085.398	14.508
1973	80474.875	69075.313	-11399.563	14.165

TABLE D-38
100% INCREASE IN FUEL PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	678.190	622.105	-56.085	8.270
1964	719.266	648.598	-70.668	9.825
1965	753.272	672.089	-81.183	10.777
1966	784.939	693.267	-91.671	11.679
1967	812.956	713.326	-99.630	12.255
1968	850.838	740.777	-110.061	12.936
1969	879.742	763.626	-116.116	13.199
1970	918.566	799.509	-119.057	12.961
1971	955.800	837.807	-117.993	12.345
1972	992.935	878.071	-114.863	11.568
1973	1031.323	919.141	-112.181	10.877

TABLE D-39
100% INCREASE IN FUEL PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	9192098.000	6021266.000	-3170832.000	34.495
1964	9052368.000	6781689.000	-2270679.000	25.084
1965	8295878.000	6729220.000	-1566658.000	18.885
1966	8408353.000	6782657.000	-1625696.000	19.334
1967	8406754.000	7119848.000	-1286906.000	15.308
1968	9595207.000	7914104.000	-1681103.000	17.520
1969	9172036.000	8037624.000	-1134412.000	12.368
1970	9586930.000	8719545.000	-867385.000	9.048
1971	9761636.000	9267778.000	-493858.000	5.059
1972	10086933.000	9685391.000	-401542.000	3.981
1973	9866894.000	9114066.000	-752828.000	7.630

TABLE D-40
100% INCREASE IN FUEL PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059965.000	6059964.000	-1.000	0.000
1964	6172939.000	6166599.000	-6340.000	0.103
1965	6269994.000	6248048.000	-21946.000	0.350
1966	6336727.000	6288085.000	-48642.000	0.768
1967	6130706.000	6032599.000	-98107.000	1.600
1968	6299147.000	6120613.000	-178534.000	2.834
1969	6389761.000	6078316.000	-311445.000	4.874
1970	6367771.000	5850221.000	-517550.000	8.128
1971	6613601.000	5828950.000	-784651.000	11.864
1972	7313076.000	6245707.000	-1067369.000	14.595
1973	7925122.000	6623206.000	-1301916.000	16.428

APPENDIX E

TABLES FOR SECTION 7.0

MULTIPLIER EXPERIMENTS
WITH THE UNCORRECTED (JFA) VERSION
OF THE DEMAND BLOCK

TABLE E-1
1% INCREASE IN UNEMPLOYMENT WITH 1% DECREASES
IN DISPOSABLE INCOME AND TARGET STOCK
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	5812329.000	-247635.000	4.086
1964	6172259.000	5980110.000	-192149.000	3.113
1965	6267486.000	6130986.000	-136500.000	2.178
1966	6330893.000	6241717.000	-89176.000	1.409
1967	6118695.000	6069187.000	-49508.000	0.809
1968	6276709.000	6245004.000	-31705.000	0.505
1969	6350000.000	6309235.000	-40765.000	0.642
1970	6300898.000	6236548.000	-64350.000	1.021
1971	6510634.000	6394736.000	-115898.000	1.780
1972	7166762.000	7005955.000	-160807.000	2.244
1973	7742069.000	7552573.000	-189496.000	2.448

TABLE E-2
1% INCREASE IN UNEMPLOYMENT WITH 1% DECREASES
IN DISPOSABLE INCOME AND TARGET STOCK
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	8555093.000	-297322.000	3.359
1964	8731029.000	8441429.000	-289600.000	3.317
1965	8031540.000	7791497.000	-240043.000	2.989
1966	8155028.000	7994169.000	-160859.000	1.973
1967	8104427.000	7984748.000	-119679.000	1.477
1968	9338275.000	9241962.000	-96313.000	1.031
1969	8979385.000	8889436.000	-89949.000	1.002
1970	9742072.000	9632461.000	-109611.000	1.125
1971	10039273.000	9897709.000	-141564.000	1.410
1972	10821622.000	10591689.000	-229933.000	2.125
1973	10336898.000	10086192.000	-250706.000	2.425

TABLE E-3
1% INCREASE IN UNEMPLOYMENT WITH 1% DECREASES
IN DISPOSABLE INCOME AND TARGET STOCK
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	62367472.000	-49696.000	0.080
1964	64975920.000	64828816.000	-147104.000	0.226
1965	66739984.000	66489296.000	-250688.000	0.376
1966	68564096.000	68241696.000	-322400.000	0.470
1967	70549808.000	70157232.000	-392576.000	0.556
1968	73611328.000	73154192.000	-457136.000	0.621
1969	76240672.000	75734336.000	-506336.000	0.664
1970	79681776.000	79130176.000	-551600.000	0.692
1971	83210368.000	82633152.000	-577216.000	0.694
1972	86865232.000	86218832.000	-646400.000	0.744
1973	89459968.000	88752400.000	-707568.000	0.791

TABLE E-4
1% INCREASE IN UNEMPLOYMENT WITH 1% DECREASES IN DISPOSABLE INCOME AND TARGET STOCK
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	672.033	-3.894	0.576
1964	714.780	710.252	-4.528	0.633
1965	746.909	741.663	-5.246	0.702
1966	776.799	771.051	-5.748	0.740
1967	802.740	796.496	-6.245	0.778
1968	838.885	832.123	-6.762	0.806
1969	866.597	859.425	-7.172	0.828
1970	906.690	899.145	-7.545	0.832
1971	946.285	938.484	-7.801	0.824
1972	989.098	980.725	-8.372	0.846
1973	1031.905	1023.031	-8.875	0.860

TABLE E-5
1% INCREASE IN UNEMPLOYMENT WITH 1% DECREASES IN DISPOSABLE INCOME AND TARGET STOCK
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	44483.324	-319.270	0.713
1964	48780.051	48381.133	-398.918	0.818
1965	52372.410	51894.871	-477.539	0.912
1966	56195.316	55664.082	-531.234	0.945
1967	59201.320	58630.996	-570.324	0.963
1968	63300.348	62691.152	-609.195	0.962
1969	66490.438	65849.625	-640.813	0.964
1970	70416.563	69745.625	-670.938	0.953
1971	73921.313	73228.375	-692.938	0.937
1972	77858.000	77120.750	-737.250	0.947
1973	81775.313	81000.563	-774.750	0.947

TABLE E-6
1% INCREASES IN POPULATION AND TARGET STOCK
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	9042496.000	190081.000	2.147
1964	8731029.000	8879650.000	148621.000	1.702
1965	8031540.000	8137605.000	106065.000	1.321
1966	8155028.000	8222746.000	67718.000	0.830
1967	8104427.000	8156018.000	51591.000	0.637
1968	9338275.000	9384603.000	46328.000	0.496
1969	8979385.000	9026048.000	46663.000	0.520
1970	9742072.000	9800714.000	58642.000	0.602
1971	10039273.000	10112737.000	73464.000	0.732
1972	10821622.000	10930698.000	109076.000	1.008
1973	10336898.000	10454297.000	117399.000	1.136

TABLE E-7
1% INCREASES IN POPULATION AND TARGET STOCK
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	6059964.000	0.0	0.0
1964	6172259.000	6172640.000	381.000	0.006
1965	6267486.000	6268827.000	1341.000	0.021
1966	6330893.000	6333902.000	3009.000	0.048
1967	6118695.000	6124711.000	6016.000	0.098
1968	6276709.000	6287569.000	10860.000	0.173
1969	6350000.000	6368769.000	18769.000	0.296
1970	6300898.000	6331834.000	30936.000	0.491
1971	6510634.000	6557290.000	46656.000	0.717
1972	7166762.000	7229712.000	62950.000	0.878
1973	7742069.000	7817770.000	75701.000	0.978

TABLE E-8
1% INCREASES IN POPULATION AND TARGET STOCK
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	62607248.000	190080.000	0.305
1964	64975920.000	65314240.000	338320.000	0.521
1965	66739984.000	67183024.000	443040.000	0.664
1966	68564096.000	69071840.000	507744.000	0.741
1967	70549808.000	71103136.000	553328.000	0.784
1968	73611328.000	74200112.000	588784.000	0.800
1969	76240672.000	76857328.000	616656.000	0.809
1970	79681776.000	80326176.000	644400.000	0.809
1971	83210368.000	83881568.000	671200.000	0.807
1972	86865232.000	87582592.000	717360.000	0.826
1973	89459968.000	90219008.000	759040.000	0.848

TABLE E-9
1% INCREASES IN POPULATION AND TARGET STOCK
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	679.901	3.974	0.588
1964	714.780	719.908	5.129	0.718
1965	746.909	752.907	5.998	0.803
1966	776.799	783.394	6.595	0.849
1967	802.740	809.765	7.025	0.875
1968	838.885	846.311	7.426	0.885
1969	866.597	874.319	7.721	0.891
1970	906.690	914.777	8.087	0.892
1971	946.285	954.718	8.433	0.891
1972	989.098	998.024	8.926	0.902
1973	1031.905	1041.361	9.455	0.916

TABLE E-10
1% INCREASES IN POPULATION AND TARGET STOCK
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	45105.227	302.633	0.675
1964	48780.051	49177.195	397.145	0.814
1965	52372.410	52840.246	467.836	0.893
1966	56195.316	56712.586	517.270	0.920
1967	59201.320	59751.168	549.848	0.929
1968	63300.348	63882.813	582.465	0.920
1969	66490.438	67097.563	607.125	0.913
1970	70416.563	71054.188	637.625	0.906
1971	73921.313	74586.250	664.938	0.900
1972	77858.000	78564.625	706.625	0.908
1973	81775.313	82527.938	752.625	0.920

TABLE E-11
10% INCREASE IN SMALL CAR NET PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	8571050.000	-281365.000	3.178
1964	8731029.000	8564501.000	-166528.000	1.907
1965	8031540.000	7988617.000	-42923.000	0.534
1966	8155028.000	8154937.000	-91.000	0.001
1967	8104427.000	8047339.000	-57088.000	0.704
1968	9338275.000	9227403.000	-110872.000	1.187
1969	8979385.000	8845912.000	-133473.000	1.486
1970	9742072.000	9623295.000	-118777.000	1.219
1971	10039273.000	9897311.000	-141962.000	1.414
1972	10821622.000	10795041.000	-26581.000	0.246
1973	10336898.000	10352149.000	15251.000	0.148

TABLE E-12
10% INCREASE IN SMALL CAR NET PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.266	0.236	-0.030	11.402
1964	0.222	0.178	-0.044	19.673
1965	0.190	0.144	-0.047	24.624
1966	0.158	0.116	-0.042	26.523
1967	0.178	0.134	-0.044	24.768
1968	0.203	0.157	-0.046	22.626
1969	0.249	0.202	-0.046	18.658
1970	0.269	0.221	-0.048	17.973
1971	0.313	0.266	-0.047	14.941
1972	0.320	0.268	-0.052	16.222
1973	0.311	0.250	-0.061	19.516

TABLE E-13
10% INCREASE IN SMALL CAR NET PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.175	0.206	0.032	18.303
1964	0.196	0.244	0.047	24.196
1965	0.228	0.281	0.053	23.439
1966	0.258	0.309	0.051	19.765
1967	0.231	0.285	0.054	23.446
1968	0.209	0.265	0.056	26.739
1969	0.166	0.221	0.054	32.712
1970	0.163	0.218	0.055	33.495
1971	0.136	0.187	0.050	36.991
1972	0.165	0.219	0.055	33.096
1973	0.203	0.267	0.064	31.321

TABLE E-14
10% INCREASE IN SMALL CAR NET PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.559	0.558	-0.002	0.288
1964	0.582	0.578	-0.004	0.646
1965	0.582	0.575	-0.006	1.110
1966	0.584	0.575	-0.009	1.535
1967	0.591	0.581	-0.010	1.707
1968	0.588	0.578	-0.010	1.690
1969	0.585	0.577	-0.008	1.357
1970	0.567	0.561	-0.006	1.100
1971	0.551	0.547	-0.004	0.666
1972	0.515	0.513	-0.003	0.504
1973	0.486	0.483	-0.003	0.611

TABLE E-15
10% INCREASE IN SMALL CAR NET PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	6026514.000	-33450.000	0.552
1964	6172259.000	6143734.000	-28525.000	0.462
1965	6267486.000	6245637.000	-21849.000	0.349
1966	6330893.000	6314788.000	-16105.000	0.254
1967	6118695.000	6105030.000	-13665.000	0.223
1968	6276709.000	6265704.000	-11005.000	0.175
1969	6350000.000	6332712.000	-17288.000	0.272
1970	6300898.000	6267828.000	-33070.000	0.525
1971	6510634.000	6458139.000	-52495.000	0.806
1972	7166762.000	7095480.000	-71282.000	0.995
1973	7742069.000	7659742.000	-82327.000	1.063

TABLE E-16
10% INCREASE IN SMALL CAR NET PRICE
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	62169248.000	-247920.000	0.397
1964	64975920.000	64590016.000	-385904.000	0.594
1965	66739984.000	66333008.000	-406976.000	0.610
1966	68564096.000	68173104.000	-390992.000	0.570
1967	70549808.000	70115376.000	-434432.000	0.616
1968	73611328.000	73077040.000	-534288.000	0.726
1969	76240672.000	75590192.000	-650480.000	0.853
1970	79681776.000	78945632.000	-736144.000	0.924
1971	83210368.000	82384800.000	-825568.000	0.992
1972	86865232.000	86084304.000	-780928.000	0.899
1973	89459968.000	88776672.000	-683296.000	0.764

TABLE E-17
10% INCREASE IN SMALL CAR NET PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	674.335	-1.592	0.236
1964	714.780	712.253	-2.527	0.353
1965	746.909	744.177	-2.731	0.366
1966	776.799	774.159	-2.640	0.340
1967	802.740	799.739	-3.001	0.374
1968	838.885	835.184	-3.701	0.441
1969	866.597	862.094	-4.504	0.520
1970	906.690	901.577	-5.113	0.564
1971	946.285	940.496	-5.789	0.612
1972	989.098	983.510	-5.587	0.565
1973	1031.905	1026.858	-5.048	0.489

TABLE E-18
10% INCREASE IN SMALL CAR NET PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	44733.336	-69.258	0.155
1964	48780.051	48728.406	-51.645	0.106
1965	52372.410	52392.375	19.965	0.038
1966	56195.316	56212.590	17.273	0.031
1967	59201.320	59309.340	108.020	0.182
1968	63300.348	63433.043	132.695	0.210
1969	66490.438	66637.813	147.375	0.222
1970	70416.563	70605.063	188.500	0.268
1971	73921.313	74224.875	303.563	0.411
1972	77858.000	78283.938	425.938	0.547
1973	81775.313	82358.875	583.563	0.714

TABLE E-19
10% INCREASE IN MEDIUM CAR NET PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	8671565.000	-180850.000	2.043
1964	8731029.000	8553859.000	-177170.000	2.029
1965	8031540.000	7845474.000	-186066.000	2.317
1966	8155028.000	7962715.000	-192313.000	2.358
1967	8104427.000	7955075.000	-149352.000	1.843
1968	9338275.000	9174028.000	-164247.000	1.759
1969	8979385.000	8819753.000	-159632.000	1.778
1970	9742072.000	9616225.000	-125847.000	1.292
1971	10039273.000	9920835.000	-118438.000	1.180
1972	10821622.000	10820986.000	-636.000	0.006
1973	10336898.000	10341202.000	4304.000	0.042

TABLE E-20
10% INCREASE IN MEDIUM CAR NET PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.175	0.136	-0.039	22.149
1964	0.196	0.138	-0.058	29.446
1965	0.228	0.158	-0.070	30.722
1966	0.258	0.178	-0.079	30.761
1967	0.231	0.151	-0.080	34.515
1968	0.209	0.133	-0.076	36.416
1969	0.166	0.101	-0.065	39.220
1970	0.163	0.103	-0.060	36.855
1971	0.136	0.086	-0.050	36.660
1972	0.165	0.112	-0.053	32.081
1973	0.203	0.141	-0.062	30.683

TABLE E-21
10% INCREASE IN MEDIUM CAR NET PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.266	0.278	0.012	4.467
1964	0.222	0.237	0.015	6.749
1965	0.190	0.208	0.018	9.194
1966	0.158	0.178	0.020	12.407
1967	0.178	0.195	0.017	9.698
1968	0.203	0.216	0.013	6.515
1969	0.249	0.252	0.003	1.189
1970	0.269	0.268	-0.002	0.673
1971	0.313	0.302	-0.011	3.561
1972	0.320	0.312	-0.008	2.655
1973	0.311	0.311	-0.000	0.130

TABLE E-22
10% INCREASE IN MEDIUM CAR NET PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.559	0.586	0.027	4.785
1964	0.582	0.625	0.043	7.349
1965	0.582	0.634	0.052	9.008
1966	0.584	0.644	0.060	10.204
1967	0.591	0.654	0.062	10.560
1968	0.588	0.651	0.063	10.692
1969	0.585	0.647	0.062	10.643
1970	0.567	0.629	0.062	10.916
1971	0.551	0.612	0.061	11.081
1972	0.515	0.577	0.061	11.901
1973	0.486	0.548	0.063	12.933

TABLE E-23
10% INCREASE IN MEDIUM CAR NET PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	6035416.000	-24548.000	0.405
1964	6172259.000	6153094.000	-19165.000	0.311
1965	6267486.000	6254371.000	-13115.000	0.209
1966	6330893.000	6319863.000	-11030.000	0.174
1967	6118695.000	6108772.000	-9923.000	0.162
1968	6276709.000	6263894.000	-12815.000	0.204
1969	6350000.000	6326829.000	-23171.000	0.365
1970	6300898.000	6262911.000	-37987.000	0.603
1971	6510634.000	6449419.000	-61215.000	0.940
1972	7166762.000	7081248.000	-85514.000	1.193
1973	7742069.000	7630233.000	-111836.000	1.445

TABLE E-24
10% INCREASE IN MEDIUM CAR NET PRICE
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	62260880.000	-156288.000	0.250
1964	64975920.000	64661616.000	-314304.000	0.484
1965	66739984.000	66252704.000	-487280.000	0.730
1966	68564096.000	67895552.000	-668544.000	0.975
1967	70549808.000	69741808.000	-808000.000	1.145
1968	73611328.000	72651904.000	-959424.000	1.303
1969	76240672.000	75144816.000	-1095856.000	1.437
1970	79681776.000	78498080.000	-1183696.000	1.486
1971	83210368.000	81969456.000	-1240912.000	1.491
1972	86865232.000	85709136.000	-1156096.000	1.331
1973	89459968.000	88420032.000	-1039936.000	1.162

TABLE E-25
10% INCREASE IN MEDIUM CAR NET PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	674.970	-0.957	0.142
1964	714.780	712.811	-1.969	0.275
1965	746.909	743.816	-3.092	0.414
1966	776.799	772.483	-4.315	0.556
1967	802.740	797.515	-5.225	0.651
1968	838.885	832.623	-6.262	0.746
1969	866.597	859.372	-7.226	0.834
1970	906.690	898.798	-7.892	0.870
1971	946.285	937.940	-8.345	0.882
1972	989.098	981.137	-7.961	0.805
1973	1031.905	1024.510	-7.396	0.717

TABLE E-26
10% INCREASE IN MEDIUM CAR NET PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	44699.684	-102.910	0.230
1964	48780.051	48629.086	-150.965	0.309
1965	52372.410	52182.824	-189.586	0.362
1966	56195.316	56019.230	-176.086	0.313
1967	59201.320	58974.574	-226.746	0.383
1968	63300.348	63093.703	-206.645	0.326
1969	66490.438	66336.875	-153.563	0.231
1970	70416.563	70357.688	-58.875	0.084
1971	73921.313	73940.438	19.125	0.026
1972	77858.000	78130.750	272.750	0.350
1973	81775.313	82351.438	576.125	0.705

TABLE E-27
10% INCREASE IN LARGE CAR NET PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	8222356.000	-630059.000	7.117
1964	8731029.000	8298974.000	-432055.000	4.948
1965	8031540.000	7785427.000	-246113.000	3.064
1966	8155028.000	7930704.000	-224324.000	2.751
1967	8104427.000	7890113.000	-214314.000	2.644
1968	9338275.000	9088113.000	-250162.000	2.679
1969	8979385.000	8794042.000	-185343.000	2.064
1970	9742072.000	9652115.000	-89957.000	0.923
1971	10039273.000	10011334.000	-27939.000	0.278
1972	10821622.000	10999395.000	177773.000	1.643
1973	10336898.000	10480682.000	143784.000	1.391

TABLE E-28
10% INCREASE IN LARGE CAR NET PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.559	0.552	-0.007	1.288
1964	0.582	0.570	-0.012	2.022
1965	0.582	0.567	-0.015	2.613
1966	0.584	0.567	-0.017	2.970
1967	0.591	0.572	-0.019	3.222
1968	0.588	0.568	-0.020	3.358
1969	0.585	0.564	-0.021	3.546
1970	0.567	0.546	-0.021	3.750
1971	0.551	0.529	-0.022	3.982
1972	0.515	0.493	-0.022	4.263
1973	0.486	0.464	-0.022	4.524

TABLE E-29
10% INCREASE IN LARGE CAR NET PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.175	0.179	0.004	2.543
1964	0.196	0.204	0.007	3.787
1965	0.228	0.238	0.010	4.564
1966	0.258	0.270	0.013	5.006
1967	0.231	0.245	0.014	6.022
1968	0.209	0.223	0.014	6.480
1969	0.166	0.178	0.012	7.204
1970	0.163	0.174	0.011	6.644
1971	0.136	0.145	0.009	6.596
1972	0.165	0.173	0.009	5.250
1973	0.203	0.213	0.010	4.698

TABLE E-30
10% INCREASE IN LARGE CAR NET PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.266	0.269	0.003	1.041
1964	0.222	0.226	0.004	1.954
1965	0.190	0.195	0.005	2.529
1966	0.158	0.163	0.004	2.815
1967	0.178	0.183	0.005	2.896
1968	0.203	0.209	0.006	3.056
1969	0.249	0.258	0.009	3.521
1970	0.269	0.280	0.010	3.876
1971	0.313	0.326	0.013	4.146
1972	0.320	0.333	0.013	4.163
1973	0.311	0.324	0.012	3.989

TABLE E-31
10% INCREASE IN LARGE CAR NET PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	672.440	-3.487	0.516
1964	714.780	708.904	-5.875	0.822
1965	746.909	739.755	-7.154	0.958
1966	776.799	768.440	-8.358	1.076
1967	802.740	793.240	-9.500	1.184
1968	838.885	828.042	-10.842	1.292
1969	866.597	855.012	-11.585	1.337
1970	906.690	895.179	-11.511	1.270
1971	946.285	935.607	-10.677	1.128
1972	989.098	980.855	-8.243	0.833
1973	1031.905	1026.138	-5.767	0.559

TABLE E-32
10% INCREASE IN LARGE CAR NET PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	5999191.000	-60773.000	1.003
1964	6172259.000	6125539.000	-46720.000	0.757
1965	6267486.000	6228367.000	-39119.000	0.624
1966	6330893.000	6300455.000	-30438.000	0.481
1967	6118695.000	6087152.000	-31543.000	0.516
1968	6276709.000	6242080.000	-34629.000	0.552
1969	6350000.000	6285696.000	-64304.000	1.013
1970	6300898.000	6202789.000	-98109.000	1.557
1971	6510634.000	6356551.000	-154083.000	2.367
1972	7166762.000	6968131.000	-198631.000	2.772
1973	7742069.000	7504808.000	-237261.000	3.065

TABLE E-33
10% INCREASE IN LARGE CAR NET PRICE
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	61847888.000	-569280.000	0.912
1964	64975920.000	64021296.000	-954624.000	1.469
1965	66739984.000	65578368.000	-1161616.000	1.741
1966	68564096.000	67208576.000	-1355520.000	1.977
1967	70549808.000	69011504.000	-1538304.000	2.180
1968	73611328.000	71857520.000	-1753808.000	2.383
1969	76240672.000	74365856.000	-1874816.000	2.459
1970	79681776.000	77815072.000	-1866704.000	2.343
1971	83210368.000	81469840.000	-1740528.000	2.092
1972	86865232.000	85501104.000	-1364128.000	1.570
1973	89459968.000	88476896.000	-983072.000	1.099

TABLE E-34
10% INCREASE IN LARGE CAR NET PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	44424.211	-378.383	0.845
1964	48780.051	48184.492	-595.559	1.221
1965	52372.410	51650.270	-722.141	1.379
1966	56195.316	55347.719	-847.598	1.508
1967	59201.320	58238.887	-962.434	1.626
1968	63300.348	62185.496	-1114.852	1.761
1969	66490.438	65265.926	-1224.512	1.842
1970	70416.563	69139.875	-1276.688	1.813
1971	73921.313	72644.125	-1277.188	1.728
1972	77858.000	76681.250	-1176.750	1.511
1973	81775.313	80685.688	-1089.625	1.332

TABLE E-35
10% INCREASE IN NET PRICE OF ALL CARS
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	7762934.000	-1089481.000	12.307
1964	8731029.000	7894848.000	-836181.000	9.577
1965	8031540.000	7450686.000	-580854.000	7.232
1966	8155028.000	7624156.000	-530872.000	6.510
1967	8104427.000	7578843.000	-525584.000	6.485
1968	9338275.000	8716403.000	-621872.000	6.659
1969	8979385.000	8422733.000	-556652.000	6.199
1970	9742072.000	9300891.000	-441181.000	4.529
1971	10039273.000	9656536.000	-382737.000	3.812
1972	10821622.000	10784988.000	-36634.000	0.339
1973	10336898.000	10381938.000	45040.000	0.436

TABLE E-36
10% INCREASE IN NET PRICE OF ALL CARS
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.266	0.254	-0.012	4.579
1964	0.222	0.204	-0.019	8.340
1965	0.190	0.171	-0.020	10.443
1966	0.158	0.142	-0.016	10.392
1967	0.178	0.159	-0.019	10.489
1968	0.203	0.183	-0.020	9.959
1969	0.249	0.225	-0.023	9.421
1970	0.269	0.243	-0.027	9.877
1971	0.313	0.282	-0.031	9.756
1972	0.320	0.288	-0.032	10.069
1973	0.311	0.278	-0.033	10.605

TABLE E-37
10% INCREASE IN NET PRICE OF ALL CARS
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.175	0.168	-0.007	3.772
1964	0.196	0.185	-0.011	5.746
1965	0.228	0.212	-0.015	6.703
1966	0.258	0.235	-0.023	8.768
1967	0.231	0.209	-0.022	9.487
1968	0.209	0.188	-0.021	10.273
1969	0.166	0.147	-0.019	11.576
1970	0.163	0.146	-0.017	10.286
1971	0.136	0.123	-0.013	9.591
1972	0.165	0.153	-0.012	7.093
1973	0.203	0.192	-0.011	5.622

TABLE E-38
10% INCREASE IN NET PRICE OF ALL CARS
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.559	0.578	0.019	3.355
1964	0.582	0.612	0.030	5.121
1965	0.582	0.617	0.035	6.039
1966	0.584	0.623	0.039	6.680
1967	0.591	0.632	0.041	6.857
1968	0.588	0.630	0.042	7.090
1969	0.585	0.628	0.043	7.301
1970	0.567	0.611	0.043	7.646
1971	0.551	0.595	0.044	7.905
1972	0.515	0.559	0.044	8.519
1973	0.486	0.530	0.044	9.150

TABLE E-39
10% INCREASE IN NET PRICE OF ALL CARS
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	5941193.000	-118771.000	1.960
1964	6172259.000	6077850.000	-94409.000	1.530
1965	6267486.000	6193294.000	-74192.000	1.184
1966	6330893.000	6272806.000	-58087.000	0.918
1967	6118695.000	6062182.000	-56513.000	0.924
1968	6276709.000	6215217.000	-61492.000	0.980
1969	6350000.000	6239332.000	-110668.000	1.743
1970	6300898.000	6121038.000	-179860.000	2.855
1971	6510634.000	6224382.000	-286252.000	4.397
1972	7166762.000	6781668.000	-385094.000	5.373
1973	7742069.000	7264563.000	-477506.000	6.168

TABLE E-40
10% INCREASE IN NET PRICE OF ALL CARS
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	61446464.000	-970704.000	1.555
1964	64975920.000	63263456.000	-1712464.000	2.636
1965	66739984.000	64520800.000	-2219184.000	3.325
1966	68564096.000	65872160.000	-2691936.000	3.926
1967	70549808.000	67388768.000	-3161040.000	4.481
1968	73611328.000	69889936.000	-3721392.000	5.055
1969	76240672.000	72073312.000	-4167360.000	5.466
1970	79681776.000	75253152.000	-4428624.000	5.558
1971	83210368.000	78685264.000	-4525104.000	5.438
1972	86865232.000	82688544.000	-4176688.000	4.808
1973	89459968.000	85805840.000	-3654128.000	4.085

TABLE E-41
10% INCREASE IN NET PRICE OF ALL CARS
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	669.923	-6.004	0.888
1964	714.780	704.080	-10.700	1.497
1965	746.909	732.948	-13.960	1.869
1966	776.799	759.784	-17.014	2.190
1967	802.740	782.659	-20.082	2.502
1968	838.885	815.128	-23.757	2.832
1969	866.597	839.872	-26.726	3.084
1970	906.690	878.157	-28.533	3.147
1971	946.285	916.998	-29.287	3.095
1972	989.098	961.838	-27.260	2.756
1973	1031.905	1007.770	-24.135	2.339

TABLE E-42
10% INCREASE IN NET PRICE OF ALL CARS
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	44235.914	-566.680	1.265
1964	48780.051	47916.391	-863.660	1.771
1965	52372.410	51352.309	-1020.102	1.948
1966	56195.316	55010.609	-1184.707	2.108
1967	59201.320	57889.813	-1311.508	2.215
1968	63300.348	61833.926	-1466.422	2.317
1969	66490.438	64935.191	-1555.246	2.339
1970	70416.563	68882.375	-1534.188	2.179
1971	73921.313	72491.625	-1429.688	1.934
1972	77858.000	76812.688	-1045.313	1.343
1973	81775.313	81236.250	-539.063	0.659

TABLE E-43
10% INCREASE IN FUEL PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	8365615.000	-486800.000	5.499
1964	8731029.000	8412712.000	-318317.000	3.646
1965	8031540.000	7826068.000	-205472.000	2.558
1966	8155028.000	7949142.000	-205886.000	2.525
1967	8104427.000	7925407.000	-179020.000	2.209
1968	9338275.000	9072796.000	-265479.000	2.843
1969	8979385.000	8771546.000	-207839.000	2.315
1970	9742072.000	9592063.000	-150009.000	1.540
1971	10039273.000	9929698.000	-109575.000	1.091
1972	10821622.000	10834125.000	12503.000	0.116
1973	10336898.000	10359097.000	22199.000	0.215

TABLE E-44
10% INCREASE IN FUEL PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	6059965.000	1.000	0.000
1964	6172259.000	6171287.000	-972.000	0.016
1965	6267486.000	6264179.000	-3307.000	0.053
1966	6330893.000	6323663.000	-7230.000	0.114
1967	6118695.000	6104228.000	-14467.000	0.236
1968	6276709.000	6250540.000	-26169.000	0.417
1969	6350000.000	6304433.000	-45567.000	0.718
1970	6300898.000	6225252.000	-75646.000	1.201
1971	6510634.000	6396347.000	-114287.000	1.755
1972	7166762.000	7011541.000	-155221.000	2.166
1973	7742069.000	7553920.000	-188149.000	2.430

TABLE E-45
10% INCREASE IN FUEL PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.266	0.261	-0.005	1.913
1964	0.222	0.215	-0.007	3.283
1965	0.190	0.183	-0.007	3.778
1966	0.158	0.150	-0.008	5.166
1967	0.178	0.172	-0.006	3.469
1968	0.203	0.195	-0.008	3.812
1969	0.249	0.238	-0.011	4.361
1970	0.269	0.256	-0.013	4.791
1971	0.313	0.298	-0.015	4.667
1972	0.320	0.304	-0.016	4.873
1973	0.311	0.296	-0.015	4.771

TABLE E-46
10% INCREASE IN FUEL PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.175	0.170	-0.004	2.551
1964	0.196	0.189	-0.007	3.601
1965	0.228	0.217	-0.010	4.545
1966	0.258	0.247	-0.011	4.183
1967	0.231	0.216	-0.015	6.343
1968	0.209	0.195	-0.014	6.594
1969	0.166	0.155	-0.011	6.586
1970	0.163	0.154	-0.009	5.637
1971	0.136	0.127	-0.009	6.427
1972	0.165	0.157	-0.008	4.805
1973	0.203	0.195	-0.009	4.240

TABLE E-47
10% INCREASE IN FUEL PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.559	0.569	0.010	1.706
1964	0.582	0.596	0.014	2.467
1965	0.582	0.599	0.018	3.014
1966	0.584	0.603	0.019	3.243
1967	0.591	0.612	0.021	3.519
1968	0.588	0.610	0.022	3.660
1969	0.585	0.607	0.022	3.729
1970	0.567	0.590	0.022	3.895
1971	0.551	0.574	0.023	4.236
1972	0.515	0.539	0.024	4.562
1973	0.486	0.509	0.023	4.833

TABLE E-48
10% INCREASE IN FUEL PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	667.869	-8.058	1.192
1964	714.780	704.628	-10.151	1.420
1965	746.909	735.313	-11.596	1.552
1966	776.799	763.820	-12.979	1.671
1967	802.740	788.598	-14.142	1.762
1968	838.885	823.026	-15.859	1.890
1969	866.597	849.513	-17.084	1.971
1970	906.690	888.955	-17.735	1.956
1971	946.285	928.385	-17.900	1.892
1972	989.098	972.000	-17.097	1.729
1973	1031.905	1015.908	-15.997	1.550

TABLE E-49
10% INCREASE IN FUEL PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	44197.672	-604.922	1.350
1964	48780.051	48043.145	-736.906	1.511
1965	52372.410	51564.480	-807.930	1.543
1966	56195.316	55308.742	-886.574	1.578
1967	59201.320	58265.469	-935.852	1.581
1968	63300.348	62281.668	-1018.680	1.609
1969	66490.438	65441.660	-1048.777	1.577
1970	70416.563	69393.438	-1023.125	1.453
1971	73921.313	72964.750	-956.563	1.294
1972	77858.000	77075.375	-782.625	1.005
1973	81775.313	81202.750	-572.563	0.700

TABLE E-50
10% INCREASE IN FUEL PRICE
TOTAL CARS IN USE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	62417168.000	61930368.000	-486800.000	0.780
1964	64975920.000	64171776.000	-804144.000	1.238
1965	66739984.000	65733680.000	-1006304.000	1.508
1966	68564096.000	67359120.000	-1204976.000	1.757
1967	70549808.000	69180288.000	-1369520.000	1.941
1968	73611328.000	72002496.000	-1608832.000	2.186
1969	76240672.000	74469584.000	-1771088.000	2.323
1970	79681776.000	77836352.000	-1845424.000	2.316
1971	83210368.000	81369632.000	-1840736.000	2.212
1972	86865232.000	85192208.000	-1673024.000	1.926
1973	89459968.000	87997296.000	-1462672.000	1.635

TABLE E-51
100% INCREASE IN FUEL PRICE
NEW CAR SALES

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	8852415.000	5351558.000	-3500857.000	39.547
1964	8731029.000	5925981.000	-2805048.000	32.127
1965	8031540.000	5744136.000	-2287404.000	28.480
1966	8155028.000	5909833.000	-2245195.000	27.531
1967	8104427.000	6023771.000	-2080656.000	25.673
1968	9338275.000	6707672.000	-2630603.000	28.170
1969	8979385.000	6601537.000	-2377848.000	26.481
1970	9742072.000	7369453.000	-2372619.000	24.354
1971	10039273.000	7731357.000	-2307916.000	22.989
1972	10821622.000	8532815.000	-2288807.000	21.150
1973	10336898.000	8259950.000	-2076948.000	20.093

TABLE E-52
100% INCREASE IN FUEL PRICE
LARGE SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.559	0.649	0.090	16.078
1964	0.582	0.706	0.125	21.408
1965	0.582	0.724	0.142	24.432
1966	0.584	0.729	0.145	24.849
1967	0.591	0.744	0.153	25.846
1968	0.588	0.742	0.154	26.176
1969	0.585	0.739	0.154	26.356
1970	0.567	0.725	0.158	27.766
1971	0.551	0.720	0.169	30.665
1972	0.515	0.690	0.175	33.971
1973	0.486	0.667	0.181	37.276

TABLE E-53
100% INCREASE IN FUEL PRICE
SMALL SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.266	0.215	-0.051	19.295
1964	0.222	0.157	-0.065	29.296
1965	0.190	0.130	-0.060	31.479
1966	0.158	0.097	-0.061	38.596
1967	0.178	0.129	-0.049	27.467
1968	0.203	0.141	-0.062	30.611
1969	0.249	0.165	-0.084	33.544
1970	0.269	0.174	-0.095	35.442
1971	0.313	0.204	-0.109	34.712
1972	0.320	0.204	-0.116	36.126
1973	0.311	0.200	-0.111	35.676

TABLE E-54
100% INCREASE IN FUEL PRICE
MEDIUM SALES SHARE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	0.175	0.136	-0.039	22.123
1964	0.196	0.137	-0.059	30.333
1965	0.228	0.145	-0.082	36.129
1966	0.258	0.173	-0.084	32.659
1967	0.231	0.127	-0.104	45.051
1968	0.209	0.117	-0.092	43.914
1969	0.166	0.096	-0.071	42.481
1970	0.163	0.101	-0.062	38.062
1971	0.136	0.076	-0.060	44.396
1972	0.165	0.105	-0.059	36.101
1973	0.203	0.133	-0.070	34.418

TABLE E-55
100% INCREASE IN FUEL PRICE
SCRAPPAGE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	6059964.000	6059965.000	1.000	0.000
1964	6172259.000	6165259.000	-7000.000	0.113
1965	6267486.000	6242661.000	-24825.000	0.396
1966	6330893.000	6274439.000	-56454.000	0.892
1967	6118695.000	6003311.000	-115384.000	1.886
1968	6276709.000	6064108.000	-212601.000	3.387
1969	6350000.000	5975320.000	-374680.000	5.900
1970	6300898.000	5671923.000	-628975.000	9.982
1971	6510634.000	5541555.000	-969079.000	14.885
1972	7166762.000	5812832.000	-1353930.000	18.892
1973	7742069.000	6031161.000	-1710908.000	22.099

TABLE E-56
100% INCREASE IN FUEL PRICE
VEHICLE MILES TRAVELED

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	675.927	617.621	-58.306	8.626
1964	714.780	638.257	-76.523	10.706
1965	746.909	654.991	-91.917	12.306
1966	776.799	670.217	-106.582	13.721
1967	802.740	682.852	-119.888	14.935
1968	838.885	702.215	-136.670	16.292
1969	866.597	715.769	-150.828	17.405
1970	906.690	743.446	-163.245	18.004
1971	946.285	773.064	-173.221	18.305
1972	989.098	807.998	-181.100	18.310
1973	1031.905	846.722	-185.183	17.946

TABLE E-57
100% INCREASE IN FUEL PRICE
GASOLINE CONSUMPTION

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1963	44802.594	40401.449	-4401.145	9.823
1964	48780.051	43093.539	-5686.512	11.657
1965	52372.410	45680.074	-6692.336	12.778
1966	56195.316	48462.102	-7733.215	13.761
1967	59201.320	50688.652	-8512.668	14.379
1968	63300.348	53772.281	-9528.066	15.052
1969	66490.438	56253.063	-10237.375	15.397
1970	70416.563	59679.480	-10737.082	15.248
1971	73921.313	62934.828	-10986.484	14.862
1972	77858.000	66946.875	-10911.125	14.014
1973	81775.313	71352.313	-10423.000	12.746

APPENDIX F

TABLES FOR SECTION 8.0
MULTIPLIER EXPERIMENTS
ON THE INDUSTRY/POLICY BLOCK OUTPUTS
USING THE FULL MODEL

TABLES F-1 TO F-18
100% INCREASE IN FUEL PRICE

TABLE F-1
STANDARD/PENALTY OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3349.343	26.394	0.794
1977	3485.824	3518.588	32.764	0.940
1978	3558.555	3609.498	50.943	1.432
1979	3635.353	3713.340	77.988	2.145
1980	3740.931	3844.748	103.817	2.775
1981	3689.527	3817.165	127.637	3.459
1982	3732.337	3816.603	84.266	2.258
1983	3820.667	3897.551	76.885	2.012
1984	3865.410	3937.024	71.614	1.853
1985	3870.027	3949.925	79.898	2.065

TABLE F-2
STANDARD/PENALTY OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3880.220	98.920	2.616
1977	3993.791	4115.188	121.396	3.040
1978	4103.375	4254.270	150.895	3.677
1979	4224.402	4397.629	173.227	4.101
1980	4348.477	4538.344	189.867	4.366
1981	4451.742	4591.156	139.414	3.132
1982	4617.355	4729.242	111.887	2.423
1983	4843.344	4912.922	69.578	1.437
1984	4960.473	5018.703	58.230	1.174
1985	5014.371	5083.012	68.641	1.369

TABLE F-3
STANDARD/PENALTY OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	5059.863	91.078	1.833
1977	5202.113	5301.016	98.902	1.901
1978	5350.273	5438.398	88.125	1.647
1979	5510.879	5581.160	70.281	1.275
1980	5633.215	5737.574	104.359	1.853
1981	6012.746	6026.094	13.348	0.222
1982	6356.934	6437.840	80.906	1.273
1983	6667.230	6758.895	91.664	1.375
1984	6829.766	6921.297	91.531	1.340
1985	6908.207	6999.563	91.355	1.322

TABLE F-4
STANDARD/PENALTY OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.640	0.400	1.650
1977	24.240	24.740	0.500	2.063
1978	24.353	24.940	0.587	2.412
1979	24.602	25.440	0.838	3.404
1980	25.427	26.840	1.413	5.557
1981	26.757	28.079	1.322	4.941
1982	28.025	29.570	1.545	5.513
1983	29.856	30.855	0.999	3.346
1984	31.135	32.157	1.021	3.280
1985	32.286	33.634	1.348	4.176

TABLE F-5
STANDARD/PENALTY OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	19.500	0.900	4.838
1977	19.120	20.320	1.200	6.276
1978	19.697	21.080	1.383	7.022
1979	20.621	22.140	1.518	7.363
1980	21.719	23.699	1.981	9.120
1981	23.887	24.889	1.003	4.198
1982	25.107	26.578	1.471	5.861
1983	25.950	27.227	1.277	4.920
1984	26.250	27.409	1.158	4.413
1985	26.261	27.527	1.266	4.823

TABLE F-6
STANDARD/PENALTY OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	16.090	0.600	3.873
1977	16.190	16.890	0.700	4.323
1978	16.766	17.490	0.724	4.320
1979	17.539	18.290	0.751	4.282
1980	18.539	19.590	1.051	5.667
1981	20.166	20.755	0.589	2.919
1982	21.004	21.951	0.947	4.510
1983	21.539	22.545	1.006	4.671
1984	21.959	22.969	1.010	4.600
1985	22.371	23.379	1.008	4.508

TABLE F-7
EXCISE TAX/REBATE OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	2941.175	3021.281	80.106	2.724
1977	3103.215	3154.612	51.397	1.656
1978	3211.433	3211.433	0.0	0.0
1979	3269.933	3329.435	59.502	1.820
1980	3332.968	3410.458	77.490	2.325
1981	3358.801	3372.558	13.757	0.410
1982	3361.252	3413.354	52.102	1.550
1983	3393.502	3401.661	8.159	0.240
1984	3355.304	3393.140	37.836	1.128
1985	3344.952	3439.964	95.012	2.840

TABLE F-8
EXCISE TAX/REBATE OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3894.479	3992.846	98.367	2.526
1977	4073.567	4219.023	145.456	3.571
1978	4207.617	4257.766	50.148	1.192
1979	4183.926	4330.230	146.305	3.497
1980	4235.738	4392.391	156.652	3.698
1981	4278.621	4327.355	48.734	1.139
1982	4307.875	4408.242	100.367	2.330
1983	4291.027	4436.320	145.293	3.386
1984	4316.762	4449.234	132.473	3.069
1985	4371.211	4461.523	90.313	2.066

TABLE F-9
EXCISE TAX/REBATE OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	5531.027	5531.027	0.0	0.0
1977	5702.766	5676.316	-26.449	0.464
1978	5678.348	5790.129	111.781	1.969
1979	5738.426	5851.484	113.059	1.970
1980	5737.582	5941.668	204.086	3.557
1981	5816.355	5934.570	118.215	2.032
1982	5776.117	5945.961	169.844	2.940
1983	5850.531	5994.145	143.613	2.455
1984	5892.887	5991.594	98.707	1.675
1985	5880.070	5982.543	102.473	1.743

TABLE F-10
EXCISE TAX/REBATE OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.540	25.540	1.000	4.075
1977	24.540	25.540	1.000	4.075
1978	25.540	25.540	0.0	0.0
1979	25.640	26.640	1.000	3.900
1980	27.540	28.739	1.200	4.357
1981	27.860	28.560	0.700	2.512
1982	28.580	29.679	1.100	3.849
1983	29.799	29.899	0.100	0.336
1984	29.619	30.219	0.600	2.026
1985	29.839	31.639	1.800	6.032

TABLE F-11
EXCISE TAX/REBATE OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	19.600	20.700	1.100	5.612
1977	20.720	22.520	1.800	8.687
1978	22.580	22.880	0.300	1.329
1979	22.540	24.539	2.000	8.872
1980	24.599	26.699	2.100	8.536
1981	24.799	25.699	0.900	3.629
1982	24.899	26.599	1.700	6.827
1983	24.599	26.699	2.100	8.536
1984	24.699	26.699	2.000	8.097
1985	25.599	26.699	1.100	4.297

TABLE F-12
EXCISE TAX/REBATE OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	16.590	16.590	0.0	0.0
1977	17.690	17.590	-0.100	0.565
1978	17.590	18.590	1.000	5.685
1979	18.590	19.590	1.000	5.379
1980	19.590	21.589	2.000	10.209
1981	20.510	21.509	1.000	4.875
1982	19.530	21.529	2.000	10.240
1983	20.550	21.749	1.200	5.839
1984	20.770	21.769	1.000	4.814
1985	20.690	21.789	1.100	5.316

TABLE F-13
NO-POLICY OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3349.343	26.394	0.794
1977	3485.824	3518.588	32.764	0.940
1978	3569.961	3609.499	39.538	1.108
1979	3655.068	3713.341	58.273	1.594
1980	3754.000	3844.749	90.750	2.417
1981	3797.766	3898.157	100.391	2.643
1982	3846.844	3951.031	104.187	2.708
1983	3890.716	4006.824	116.108	2.984
1984	3938.451	4059.390	120.939	3.071
1985	3983.432	4106.211	122.779	3.082

TABLE F-14
NO-POLICY OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3880.220	98.920	2.616
1977	3993.791	4115.188	121.396	3.040
1978	4107.555	4254.273	146.719	3.572
1979	4224.148	4397.633	173.484	4.107
1980	4343.219	4538.348	195.129	4.493
1981	4385.695	4581.098	195.402	4.455
1982	4425.832	4621.391	195.559	4.419
1983	4463.422	4659.438	196.016	4.392
1984	4498.383	4685.289	186.906	4.155
1985	4530.730	4719.570	188.840	4.168

TABLE F-15
NO-POLICY OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	5059.863	91.078	1.833
1977	5202.113	5301.016	98.902	1.901
1978	5317.039	5438.402	121.363	2.283
1979	5441.051	5581.168	140.117	2.575
1980	5575.586	5737.582	161.996	2.905
1981	5605.645	5779.832	174.188	3.107
1982	5642.641	5833.137	190.496	3.376
1983	5677.438	5866.797	189.359	3.335
1984	5709.301	5909.617	200.316	3.509
1985	5746.348	5960.199	213.852	3.722

TABLE F-16
NO-POLICY OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.640	0.400	1.650
1977	24.240	24.740	0.500	2.063
1978	24.340	24.940	0.600	2.465
1979	24.540	25.440	0.900	3.667
1980	25.340	26.840	1.500	5.919
1981	25.760	27.460	1.700	6.599
1982	26.380	28.180	1.800	6.823
1983	27.000	29.099	2.100	7.777
1984	27.920	30.219	2.300	8.237
1985	29.139	31.639	2.500	8.579

TABLE F-17
NO-POLICY OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	19.500	0.900	4.838
1977	19.120	20.320	1.200	6.276
1978	19.580	21.080	1.500	7.660
1979	20.240	22.140	1.900	9.387
1980	21.300	23.699	2.400	11.267
1981	21.500	23.899	2.400	11.162
1982	21.700	24.099	2.400	11.059
1983	21.900	24.299	2.400	10.958
1984	22.100	24.399	2.300	10.406
1985	22.300	24.599	2.300	10.313

TABLE F-18
NO-POLICY OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	16.090	0.600	3.873
1977	16.190	16.890	0.700	4.323
1978	16.590	17.490	0.900	5.424
1979	17.190	18.290	1.100	6.399
1980	18.190	19.590	1.400	7.696
1981	18.210	19.710	1.500	8.237
1982	18.330	19.930	1.600	8.728
1983	18.450	20.050	1.600	8.671
1984	18.570	20.270	1.700	9.154
1985	18.790	20.590	1.800	9.579

TABLES F-19 TO F-36
10% INCREASE IN TECHNOLOGICAL ADD-ON
COST CURVE PARAMETERS

TABLE F-19
STANDARD/PENALTY OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3322.206	-0.743	0.022
1977	3485.824	3485.679	-0.145	0.004
1978	3558.555	3532.161	-26.393	0.742
1979	3635.353	3591.388	-43.964	1.209
1980	3740.931	3669.593	-71.339	1.907
1981	3689.527	3650.347	-39.180	1.062
1982	3732.337	3730.352	-1.985	0.053
1983	3820.667	3849.804	29.138	0.763
1984	3865.410	3908.332	42.922	1.110
1985	3870.027	3923.688	53.660	1.387

TABLE F-20
STANDARD/PENALTY OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3773.640	-7.660	0.203
1977	3993.791	3981.837	-11.954	0.299
1978	4103.375	4076.478	-26.897	0.655
1979	4224.402	4191.738	-32.664	0.773
1980	4348.477	4325.867	-22.609	0.520
1981	4451.742	4491.938	40.195	0.903
1982	4617.355	4719.996	102.641	2.223
1983	4843.344	4996.473	153.129	3.162
1984	4960.473	5151.082	190.609	3.843
1985	5014.371	5216.246	201.875	4.026

TABLE F-21
STANDARD/PENALTY OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	4959.473	-9.313	0.187
1977	5202.113	5186.121	-15.992	0.307
1978	5350.273	5384.680	34.406	0.643
1979	5510.879	5585.086	74.207	1.347
1980	5633.215	5741.781	108.566	1.927
1981	6012.746	6121.645	108.898	1.811
1982	6356.934	6455.664	98.730	1.553
1983	6667.230	6814.508	147.277	2.209
1984	6829.766	7006.879	177.113	2.593
1985	6908.207	7109.254	201.047	2.910

TABLE F-22
STANDARD/PENALTY OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.240	0.0	0.0
1977	24.240	24.240	0.0	0.0
1978	24.353	24.290	-0.063	0.257
1979	24.602	24.527	-0.076	0.308
1980	25.427	25.214	-0.212	0.835
1981	26.757	26.125	-0.632	2.361
1982	28.025	27.115	-0.910	3.246
1983	29.856	28.502	-1.354	4.536
1984	31.135	29.612	-1.524	4.894
1985	32.286	30.516	-1.770	5.483

TABLE F-23
STANDARD/PENALTY OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	18.500	-0.100	0.538
1977	19.120	18.920	-0.200	1.046
1978	19.697	19.549	-0.148	0.750
1979	20.621	20.407	-0.214	1.039
1980	21.719	21.509	-0.209	0.964
1981	23.887	22.697	-1.189	4.978
1982	25.107	23.168	-1.939	7.724
1983	25.950	23.748	-2.202	8.485
1984	26.250	23.995	-2.256	8.593
1985	26.261	24.000	-2.260	8.607

TABLE F-24
STANDARD/PENALTY OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	15.390	-0.100	0.646
1977	16.190	15.990	-0.200	1.235
1978	16.766	16.681	-0.084	0.503
1979	17.539	17.464	-0.074	0.424
1980	18.539	18.488	-0.051	0.277
1981	20.166	19.184	-0.982	4.870
1982	21.004	19.530	-1.474	7.020
1983	21.539	19.950	-1.590	7.380
1984	21.959	20.170	-1.790	8.150
1985	22.371	20.390	-1.981	8.856

TABLE F-25
EXCISE TAX/REBATE OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	2941.175	2941.711	0.536	0.018
1977	3103.215	3105.498	2.283	0.074
1978	3211.433	3183.677	-27.756	0.864
1979	3269.933	3286.411	16.478	0.504
1980	3332.968	3348.161	15.194	0.456
1981	3358.801	3353.993	-4.808	0.143
1982	3361.252	3395.845	34.593	1.029
1983	3393.502	3404.872	11.369	0.335
1984	3355.304	3404.996	49.692	1.481
1985	3344.952	3402.052	57.100	1.707

TABLE F-26
EXCISE TAX/REBATE OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3894.479	3940.633	46.154	1.185
1977	4073.567	4052.195	-21.372	0.525
1978	4207.617	4143.605	-64.012	1.521
1979	4183.926	4218.914	34.988	0.836
1980	4235.738	4274.871	39.133	0.924
1981	4278.621	4317.109	38.488	0.900
1982	4307.875	4317.465	9.590	0.223
1983	4291.027	4354.480	63.453	1.479
1984	4316.762	4376.480	59.719	1.383
1985	4371.211	4450.293	79.082	1.809

TABLE F-27
EXCISE TAX/REBATE OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	5531.027	5483.844	-47.184	0.853
1977	5702.766	5625.488	-77.277	1.355
1978	5678.348	5740.383	62.035	1.092
1979	5738.426	5755.578	17.152	0.299
1980	5737.582	5787.348	49.766	0.867
1981	5816.355	5823.371	7.016	0.121
1982	5776.117	5824.883	48.766	0.844
1983	5850.531	5854.840	4.309	0.074
1984	5892.887	5953.133	60.246	1.022
1985	5880.070	5987.816	107.746	1.832

TABLE F-28
EXCISE TAX/REBATE OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.540	24.540	0.0	0.0
1977	24.540	24.540	0.0	0.0
1978	25.540	24.540	-1.000	3.915
1979	25.640	25.540	-0.100	0.390
1980	27.540	26.540	-1.000	3.631
1981	27.860	26.560	-1.300	4.666
1982	28.580	27.580	-1.000	3.499
1983	29.799	27.800	-2.000	6.711
1984	29.619	28.620	-1.000	3.376
1985	29.839	29.639	-0.200	0.670

TABLE F-29
EXCISE TAX/REBATE OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	19.600	19.700	0.100	0.510
1977	20.720	19.620	-1.100	5.308
1978	22.580	20.580	-2.000	8.857
1979	22.540	21.540	-1.000	4.436
1980	24.599	22.700	-1.900	7.723
1981	24.799	22.800	-2.000	8.064
1982	24.899	22.600	-2.300	9.236
1983	24.599	22.700	-1.900	7.723
1984	24.699	22.700	-2.000	8.097
1985	25.599	23.599	-2.000	7.812

TABLE F-30
EXCISE TAX/REBATE OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	16.590	15.590	-1.000	6.027
1977	17.690	16.590	-1.100	6.218
1978	17.590	17.590	0.0	0.0
1979	18.590	17.690	-0.900	4.841
1980	19.590	18.690	-0.900	4.594
1981	20.510	18.710	-1.800	8.776
1982	19.530	18.530	-1.000	5.120
1983	20.550	18.550	-2.000	9.732
1984	20.770	19.570	-1.200	5.777
1985	20.690	19.690	-1.000	4.833

TABLE F-31
NO-POLICY OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3322.206	-0.743	0.022
1977	3485.824	3485.679	-0.145	0.004
1978	3569.961	3565.897	-4.064	0.114
1979	3655.068	3652.763	-2.305	0.063
1980	3754.000	3744.028	-9.971	0.266
1981	3797.766	3785.833	-11.933	0.314
1982	3846.844	3829.817	-17.028	0.443
1983	3890.716	3874.456	-16.260	0.418
1984	3938.451	3921.329	-17.123	0.435
1985	3983.432	3964.964	-18.468	0.464

TABLE F-32
NO-POLICY OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3773.640	-7.660	0.203
1977	3993.791	3981.837	-11.954	0.299
1978	4107.555	4092.145	-15.410	0.375
1979	4224.148	4201.816	-22.332	0.529
1980	4343.219	4315.145	-28.074	0.646
1981	4385.695	4355.871	-29.824	0.680
1982	4425.832	4394.625	-31.207	0.705
1983	4463.422	4431.063	-32.359	0.725
1984	4498.383	4471.895	-26.488	0.589
1985	4530.730	4503.047	-27.684	0.611

TABLE F-33
NO-POLICY OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	4959.473	-9.313	0.187
1977	5202.113	5186.121	-15.992	0.307
1978	5317.039	5304.488	-12.551	0.236
1979	5441.051	5424.949	-16.102	0.296
1980	5575.586	5554.523	-21.063	0.378
1981	5605.645	5578.723	-26.922	0.480
1982	5642.641	5610.742	-31.898	0.565
1983	5677.438	5641.117	-36.320	0.640
1984	5709.301	5678.887	-30.414	0.533
1985	5746.348	5704.066	-42.281	0.736

TABLE F-34
NO-POLICY OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.240	0.0	0.0
1977	24.240	24.240	0.0	0.0
1978	24.340	24.240	-0.100	0.411
1979	24.540	24.440	-0.100	0.407
1980	25.340	24.940	-0.400	1.578
1981	25.760	25.260	-0.500	1.941
1982	26.380	25.680	-0.700	2.653
1983	27.000	26.200	-0.800	2.963
1984	27.920	26.920	-1.000	3.581
1985	29.139	27.840	-1.300	4.461

TABLE F-35
NO-POLICY OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	18.500	-0.100	0.538
1977	19.120	18.920	-0.200	1.046
1978	19.580	19.280	-0.300	1.532
1979	20.240	19.740	-0.500	2.470
1980	21.300	20.500	-0.800	3.756
1981	21.500	20.600	-0.900	4.186
1982	21.700	20.700	-1.000	4.608
1983	21.900	20.800	-1.100	5.022
1984	22.100	21.000	-1.100	4.977
1985	22.300	21.100	-1.200	5.381

TABLE F-36
NO-POLICY OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	15.390	-0.100	0.646
1977	16.190	15.990	-0.200	1.235
1978	16.590	16.390	-0.200	1.205
1979	17.190	16.890	-0.300	1.745
1980	18.190	17.690	-0.500	2.749
1981	18.210	17.610	-0.600	3.295
1982	18.330	17.630	-0.700	3.819
1983	18.450	17.650	-0.800	4.336
1984	18.570	17.770	-0.800	4.308
1985	18.790	17.790	-1.000	5.322

TABLES F-37 TO F-54
50% INCREASE IN PERCEIVED LIFETIME MILES
DRIVEN PER CAR PARAMETER

TABLE F-37
STANDARD/PENALTY OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3333.733	10.785	0.325
1977	3485.824	3502.965	17.142	0.492
1978	3558.555	3586.827	28.272	0.794
1979	3635.353	3672.915	37.562	1.033
1980	3740.931	3796.239	55.307	1.478
1981	3689.527	3747.586	58.059	1.574
1982	3732.337	3773.553	41.217	1.104
1983	3820.667	3855.307	34.641	0.907
1984	3865.410	3899.753	34.344	0.888
1985	3870.027	3904.992	34.965	0.903

TABLE F-38
STANDARD/PENALTY OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIF
1976	3781.300	3818.319	37.019	0.979
1977	3993.791	4046.693	52.902	1.325
1978	4103.375	4166.930	63.555	1.549
1979	4224.402	4305.438	81.035	1.918
1980	4348.477	4437.125	88.648	2.039
1981	4451.742	4514.652	62.910	1.413
1982	4617.355	4668.367	51.012	1.105
1983	4843.344	4862.328	18.984	0.392
1984	4960.473	4981.211	20.738	0.418
1985	5014.371	5033.063	18.691	0.373

TABLE F-39
STANDARD/PENALTY OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	5007.508	38.723	0.779
1977	5202.113	5252.125	50.012	0.961
1978	5350.273	5375.797	25.523	0.477
1979	5510.879	5543.828	32.949	0.598
1980	5633.215	5657.738	24.523	0.435
1981	6012.746	6025.188	12.441	0.207
1982	6356.934	6389.855	32.922	0.518
1983	6667.230	6706.996	39.766	0.596
1984	6829.766	6869.008	39.242	0.575
1985	6908.207	6948.449	40.242	0.583

TABLE F-40
STANDARD/PENALTY OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.440	0.200	0.825
1977	24.240	24.540	0.300	1.238
1978	24.353	24.640	0.287	1.180
1979	24.602	25.065	0.463	1.881
1980	25.427	26.140	0.713	2.805
1981	26.757	27.481	0.725	2.708
1982	28.025	28.855	0.830	2.961
1983	29.856	30.106	0.250	0.836
1984	31.135	31.580	0.444	1.427
1985	32.286	32.726	0.440	1.362

TABLE F-41
STANDARD/PENALTY OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	19.000	0.400	2.150
1977	19.120	19.720	0.600	3.138
1978	19.697	20.280	0.583	2.961
1979	20.621	21.433	0.812	3.938
1980	21.719	22.600	0.881	4.055
1981	23.887	24.481	0.594	2.488
1982	25.107	25.885	0.778	3.100
1983	25.950	26.531	0.582	2.241
1984	26.250	26.826	0.575	2.192
1985	26.261	26.851	0.590	2.249

TABLE F-42
STANDARD/PENALTY OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	15.790	0.300	1.937
1977	16.190	16.590	0.400	2.470
1978	16.766	17.090	0.324	1.934
1979	17.539	17.966	0.427	2.433
1980	18.539	18.990	0.451	2.431
1981	20.166	20.548	0.382	1.893
1982	21.004	21.476	0.472	2.245
1983	21.539	22.045	0.506	2.350
1984	21.959	22.465	0.506	2.305
1985	22.371	22.879	0.508	2.273

TABLE F-43
EXCISE TAX/REBATE OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	2941.175	2941.175	0.0	0.0
1977	3103.215	3154.612	51.397	1.656
1978	3211.433	3211.433	0.0	0.0
1979	3269.933	3329.435	59.502	1.820
1980	3332.968	3332.968	0.0	0.0
1981	3358.801	3372.558	13.757	0.410
1982	3361.252	3413.354	52.102	1.550
1983	3393.502	3401.661	8.159	0.240
1984	3355.304	3361.293	5.989	0.179
1985	3344.952	3377.743	32.792	0.980

TABLE F-44
EXCISE TAX/REBATE OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3894.479	3992.846	98.367	2.526
1977	4073.567	4128.824	55.257	1.356
1978	4207.617	4207.617	0.0	0.0
1979	4183.926	4272.891	88.965	2.126
1980	4235.738	4247.309	11.570	0.273
1981	4278.621	4327.355	48.734	1.139
1982	4307.875	4356.156	48.281	1.121
1983	4291.027	4421.969	130.941	3.052
1984	4316.762	4358.840	42.078	0.975
1985	4371.211	4383.582	12.371	0.283

TABLE F-45
EXCISE TAX/REBATE OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	5531.027	5531.027	0.0	0.0
1977	5702.766	5676.316	-26.449	0.464
1978	5678.348	5790.129	111.781	1.969
1979	5738.426	5851.484	113.059	1.970
1980	5737.582	5831.227	93.645	1.632
1981	5816.355	5834.797	18.441	0.317
1982	5776.117	5945.961	169.844	2.940
1983	5850.531	5867.488	16.957	0.290
1984	5892.887	5971.328	78.441	1.331
1985	5880.070	5963.551	83.480	1.420

TABLE F-46
EXCISE TAX/REBATE OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.540	24.540	0.0	0.0
1977	24.540	25.540	1.000	4.075
1978	25.540	25.540	0.0	0.0
1979	25.640	26.640	1.000	3.900
1980	27.540	27.540	0.0	0.0
1981	27.860	28.560	0.700	2.512
1982	28.580	29.679	1.100	3.849
1983	29.799	29.899	0.100	0.336
1984	29.619	29.719	0.100	0.338
1985	29.839	30.539	0.700	2.346

TABLE F-47
EXCISE TAX/REBATE OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	19.600	20.700	1.100	5.612
1977	20.720	21.620	0.900	4.343
1978	22.580	22.580	0.0	0.0
1979	22.540	23.739	1.200	5.323
1980	24.599	24.699	0.100	0.406
1981	24.799	25.699	0.900	3.629
1982	24.899	25.799	0.900	3.614
1983	24.599	26.599	2.000	8.130
1984	24.699	25.599	0.900	3.643
1985	25.599	25.699	0.100	0.391

TABLE F-48
EXCISE TAX/REBATE OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	16.590	16.590	0.0	0.0
1977	17.690	17.590	-0.100	0.565
1978	17.590	18.590	1.000	5.685
1979	18.590	19.590	1.000	5.379
1980	19.590	20.690	1.100	5.615
1981	20.510	20.610	0.100	0.488
1982	19.530	21.529	2.000	10.240
1983	20.550	20.650	0.100	0.487
1984	20.770	21.669	0.900	4.333
1985	20.690	21.689	1.000	4.833

TABLE F-49
NO-POLICY OPTION
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3333.733	10.785	0.325
1977	3485.824	3502.965	17.142	0.492
1978	3569.961	3586.828	16.868	0.472
1979	3655.068	3683.026	27.958	0.765
1980	3754.000	3796.239	42.240	1.125
1981	3797.766	3844.003	46.238	1.217
1982	3846.844	3898.082	51.237	1.332
1983	3890.716	3949.362	58.646	1.507
1984	3938.451	3998.846	60.395	1.533
1985	3983.432	4043.993	60.561	1.520

TABLE F-50
NO-POLICY OPTION
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3818.319	37.019	0.979
1977	3993.791	4046.693	52.902	1.325
1978	4107.555	4166.934	59.379	1.446
1979	4224.148	4304.887	80.738	1.911
1980	4343.219	4437.129	93.910	2.162
1981	4385.695	4479.914	94.219	2.148
1982	4425.832	4520.086	94.254	2.130
1983	4463.422	4557.680	94.258	2.112
1984	4498.383	4592.836	94.453	2.100
1985	4530.730	4625.758	95.027	2.097

TABLE F-51
NO-POLICY OPTION
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	5007.508	38.723	0.779
1977	5202.113	5252.125	50.012	0.961
1978	5317.039	5375.801	58.762	1.105
1979	5441.051	5507.746	66.695	1.226
1980	5575.586	5657.746	82.160	1.474
1981	5605.645	5687.074	81.430	1.453
1982	5642.641	5725.469	82.828	1.468
1983	5677.438	5772.402	94.965	1.673
1984	5709.301	5802.922	93.621	1.640
1985	5746.348	5840.059	93.711	1.631

TABLE F-52
NO-POLICY OPTION
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.440	0.200	0.825
1977	24.240	24.540	0.300	1.238
1978	24.340	24.640	0.300	1.232
1979	24.540	25.040	0.500	2.037
1980	25.340	26.140	0.800	3.157
1981	25.760	26.660	0.900	3.493
1982	26.380	27.380	1.000	3.790
1983	27.000	28.200	1.200	4.444
1984	27.920	29.219	1.300	4.656
1985	29.139	30.539	1.400	4.804

TABLE F-53
NO-POLICY OPTION
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	19.000	0.400	2.150
1977	19.120	19.720	0.600	3.138
1978	19.580	20.280	0.700	3.575
1979	20.240	21.240	1.000	4.940
1980	21.300	22.600	1.300	6.103
1981	21.500	22.800	1.300	6.046
1982	21.700	23.000	1.300	5.990
1983	21.900	23.199	1.300	5.936
1984	22.100	23.399	1.300	5.882
1985	22.300	23.599	1.300	5.829

TABLE F-54
NO-POLICY OPTION
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	15.790	0.300	1.937
1977	16.190	16.590	0.400	2.470
1978	16.590	17.090	0.500	3.014
1979	17.190	17.790	0.600	3.490
1980	18.190	18.990	0.800	4.398
1981	18.210	19.010	0.800	4.393
1982	18.330	19.130	0.800	4.364
1983	18.450	19.350	0.900	4.878
1984	18.570	19.470	0.900	4.846
1985	18.790	19.690	0.900	4.789

TABLES F-55 TO F-60
25% INCREASE IN STANDARD
(STANDARD/PENALTY OPTION)

TABLE F-55
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3322.949	0.0	0.0
1977	3485.824	3485.824	0.0	0.0
1978	3558.555	3468.517	-90.038	2.530
1979	3635.353	3605.145	-30.207	0.831
1980	3740.931	3730.693	-10.238	0.274
1981	3689.527	3917.004	227.477	6.165
1982	3732.337	4130.648	398.312	10.672
1983	3820.667	4339.160	518.494	13.571
1984	3865.410	4391.461	526.051	13.609
1985	3870.027	4336.617	466.590	12.056

TABLE F-56
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3781.300	0.0	0.0
1977	3993.791	3993.791	0.0	0.0
1978	4103.375	4401.594	298.219	7.268
1979	4224.402	4581.051	356.648	8.443
1980	4348.477	4685.695	337.219	7.755
1981	4451.742	4994.848	543.105	12.200
1982	4617.355	5334.848	717.492	15.539
1983	4843.344	5683.602	840.258	17.349
1984	4960.473	5877.555	917.082	18.488
1985	5014.371	5984.164	969.793	19.340

TABLE F-57
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	4968.785	0.0	0.0
1977	5202.113	5202.113	0.0	0.0
1978	5350.273	6115.309	765.035	14.299
1979	5510.879	6319.965	809.086	14.682
1980	5633.215	6457.266	824.051	14.628
1981	6012.746	6881.910	869.164	14.455
1982	6356.934	7333.316	976.383	15.359
1983	6667.230	7806.066	1138.836	17.081
1984	6829.766	8045.246	1215.480	17.797
1985	6908.207	8147.672	1239.465	17.942

TABLE F-58
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.240	0.0	0.0
1977	24.240	24.240	0.0	0.0
1978	24.353	24.996	0.643	2.642
1979	24.602	25.751	1.148	4.668
1980	25.427	27.510	2.084	8.195
1981	26.757	29.217	2.460	9.195
1982	28.025	31.079	3.054	10.897
1983	29.856	32.699	2.843	9.522
1984	31.135	34.319	3.184	10.225
1985	32.286	35.839	3.553	11.004

TABLE F-59
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	18.600	0.0	0.0
1977	19.120	19.120	0.0	0.0
1978	19.697	21.894	2.197	11.155
1979	20.621	23.456	2.835	13.747
1980	21.719	25.431	3.712	17.093
1981	23.887	26.517	2.631	11.013
1982	25.107	27.499	2.392	9.529
1983	25.950	28.099	2.149	8.283
1984	26.250	28.399	2.149	8.186
1985	26.261	28.499	2.238	8.523

TABLE F-60
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	15.490	0.0	0.0
1977	16.190	16.190	0.0	0.0
1978	16.766	18.190	1.424	8.495
1979	17.539	19.190	1.651	9.413
1980	18.539	20.885	2.346	12.657
1981	20.166	21.509	1.343	6.661
1982	21.004	22.129	1.125	5.358
1983	21.539	22.749	1.210	5.618
1984	21.959	23.269	1.310	5.966
1985	22.371	23.689	1.319	5.894

TABLES F-61 TO F-66
100% INCREASE IN PENALTY
(STANDARD/PENALTY OPTION)

TABLE F-61
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3322.949	3322.949	0.0	0.0
1977	3485.824	3485.824	0.0	0.0
1978	3558.555	3558.555	0.0	0.0
1979	3635.353	3635.353	0.0	0.0
1980	3740.931	3736.014	-4.917	0.131
1981	3689.527	3675.892	-13.635	0.370
1982	3732.337	3627.225	-105.112	2.816
1983	3820.667	3648.115	-172.552	4.516
1984	3865.410	3671.731	-193.678	5.011
1985	3870.027	3653.317	-216.710	5.600

TABLE F-62
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3781.300	3781.300	0.0	0.0
1977	3993.791	3993.791	0.0	0.0
1978	4103.375	4103.375	0.0	0.0
1979	4224.402	4224.402	0.0	0.0
1980	4348.477	4346.055	-2.422	0.056
1981	4451.742	4451.070	-0.672	0.015
1982	4617.355	4568.523	-48.832	1.058
1983	4843.344	4805.859	-37.484	0.774
1984	4960.473	4966.242	5.770	0.116
1985	5014.371	5045.285	30.914	0.617

TABLE F-63
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	4968.785	4968.785	0.0	0.0
1977	5202.113	5202.113	0.0	0.0
1978	5350.273	5350.273	0.0	0.0
1979	5510.879	5510.879	0.0	0.0
1980	5633.215	5649.148	15.934	0.283
1981	6012.746	6027.461	14.715	0.245
1982	6356.934	6571.102	214.168	3.369
1983	6667.230	7122.246	455.016	6.825
1984	6829.766	7375.598	545.832	7.992
1985	6908.207	7460.637	552.430	7.997

TABLE F-64
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.240	24.240	0.0	0.0
1977	24.240	24.240	0.0	0.0
1978	24.353	24.353	0.0	0.0
1979	24.602	24.602	0.0	0.0
1980	25.427	25.451	0.024	0.095
1981	26.757	26.821	0.065	0.242
1982	28.025	28.576	0.551	1.965
1983	29.856	30.636	0.780	2.613
1984	31.135	32.451	1.316	4.227
1985	32.286	33.323	1.037	3.212

TABLE F-65
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	18.600	18.600	0.0	0.0
1977	19.120	19.120	0.0	0.0
1978	19.697	19.697	0.0	0.0
1979	20.621	20.621	0.0	0.0
1980	21.719	21.829	0.110	0.506
1981	23.887	24.026	0.140	0.586
1982	25.107	25.971	0.865	3.444
1983	25.950	27.741	1.791	6.902
1984	26.250	28.603	2.353	8.965
1985	26.261	28.496	2.236	8.513

TABLE F-66
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	15.490	15.490	0.0	0.0
1977	16.190	16.190	0.0	0.0
1978	16.766	16.766	0.0	0.0
1979	17.539	17.539	0.0	0.0
1980	18.539	18.653	0.114	0.617
1981	20.166	20.247	0.081	0.400
1982	21.004	22.088	1.084	5.159
1983	21.539	23.323	1.784	8.280
1984	21.959	24.004	2.045	9.311
1985	22.371	24.406	2.035	9.098

TABLES F-67 TO F-72
100% INCREASE IN TAX/REBATE SCHEDULE
(EXCISE TAX/REBATE OPTION)

TABLE F-67
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	2941.175	2560.032	-381.144	12.959
1977	3103.215	2693.363	-409.853	13.207
1978	3211.433	2750.184	-461.250	14.363
1979	3269.933	2811.240	-458.692	14.028
1980	3332.968	2800.336	-532.632	15.981
1981	3358.801	2790.633	-568.168	16.916
1982	3361.252	2737.329	-623.923	18.562
1983	3393.502	2727.253	-666.250	19.633
1984	3355.304	2689.054	-666.250	19.857
1985	3344.952	2678.703	-666.249	19.918

TABLE F-68
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3894.479	3952.825	58.346	1.498
1977	4073.567	3958.321	-115.246	2.829
1978	4207.617	3978.258	-229.360	5.451
1979	4183.926	3930.484	-253.441	6.058
1980	4235.738	3874.201	-361.538	8.535
1981	4278.621	3904.478	-374.143	8.744
1982	4307.875	3968.251	-339.624	7.884
1983	4291.027	3903.779	-387.249	9.025
1984	4316.762	3916.685	-400.077	9.268
1985	4371.211	3928.919	-442.292	10.118

TABLE F-69
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	5531.027	5883.746	352.719	6.377
1977	5702.766	5981.801	279.035	4.893
1978	5678.348	5895.328	216.980	3.821
1979	5738.426	5851.484	113.059	1.970
1980	5737.582	5759.965	22.383	0.390
1981	5816.355	5752.867	-63.488	1.092
1982	5776.117	5846.820	70.703	1.224
1983	5850.531	5841.070	-9.461	0.162
1984	5892.887	5828.316	-64.570	1.096
1985	5880.070	5830.637	-49.434	0.841

TABLE F-70
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.540	25.540	1.000	4.075
1977	24.540	25.540	1.000	4.075
1978	25.540	25.540	0.0	0.0
1979	25.640	26.640	1.000	3.900
1980	27.540	29.539	2.000	7.262
1981	27.860	29.759	1.900	6.819
1982	28.580	29.579	1.000	3.499
1983	29.799	29.799	0.0	0.0
1984	29.619	29.619	0.0	0.0
1985	29.839	29.839	0.0	0.0

TABLE F-71
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	19.600	21.700	2.100	10.713
1977	20.720	22.520	1.800	8.687
1978	22.580	23.579	1.000	4.428
1979	22.540	24.539	2.000	8.872
1980	24.599	26.699	2.100	8.536
1981	24.799	26.799	2.000	8.064
1982	24.899	27.799	2.900	11.646
1983	24.599	26.599	2.000	8.130
1984	24.699	26.599	1.900	7.692
1985	25.599	26.599	1.000	3.906

TABLE F-72
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	16.590	16.590	0.0	0.0
1977	17.690	18.590	0.900	5.087
1978	17.590	18.590	1.000	5.685
1979	18.590	19.590	1.000	5.379
1980	19.590	21.589	2.000	10.209
1981	20.510	21.509	1.000	4.875
1982	19.530	22.529	3.000	15.360
1983	20.550	22.549	2.000	9.732
1984	20.770	22.569	1.800	8.666
1985	20.690	22.689	2.000	9.666

TABLES F-73 TO F-78
VALGPM PARAMETER CORRESPONDS TO
AN EXCISE TAX TABLE ZERO POINT OF 20 MPG
(EXCISE TAX/REBATE OPTION)

TABLE F-73
SMALL CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	2941.175	2941.175	0.0	0.0
1977	3103.215	3103.215	0.0	0.0
1978	3211.433	3211.433	0.0	0.0
1979	3269.933	3260.787	-9.146	0.280
1980	3332.968	3311.595	-21.373	0.641
1981	3358.801	3342.555	-16.246	0.484
1982	3361.252	3403.579	42.326	1.259
1983	3393.502	3385.494	-8.009	0.236
1984	3355.304	3367.408	12.104	0.361
1985	3344.952	3349.323	4.371	0.131

TABLE F-74
MEDIUM CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	3894.479	3909.330	14.851	0.381
1977	4073.567	4059.610	-13.957	0.343
1978	4207.617	4207.617	0.0	0.0
1979	4183.926	4221.438	37.512	0.897
1980	4235.738	4282.957	47.219	1.115
1981	4278.621	4267.172	-11.449	0.268
1982	4307.875	4296.516	-11.359	0.264
1983	4291.027	4323.930	32.902	0.767
1984	4316.762	4349.621	32.859	0.761
1985	4371.211	4319.820	-51.391	1.176

TABLE F-75
LARGE CAR NET PRICE

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	5531.027	5531.027	0.0	0.0
1977	5702.766	5702.766	0.0	0.0
1978	5678.348	5697.105	18.758	0.330
1979	5738.426	5757.137	18.711	0.326
1980	5737.582	5767.773	30.191	0.526
1981	5816.355	5816.355	0.0	0.0
1982	5776.117	5853.496	77.379	1.340
1983	5850.531	5850.531	0.0	0.0
1984	5892.887	5892.887	0.0	0.0
1985	5880.070	5865.020	-15.051	0.256

TABLE F-76
SMALL CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	24.540	24.540	0.0	0.0
1977	24.540	24.540	0.0	0.0
1978	25.540	25.540	0.0	0.0
1979	25.640	25.540	-0.100	0.390
1980	27.540	26.640	-0.900	3.268
1981	27.860	27.660	-0.200	0.718
1982	28.580	29.579	1.000	3.499
1983	29.799	29.699	-0.100	0.336
1984	29.619	29.819	0.200	0.675
1985	29.839	29.939	0.100	0.335

TABLE F-77
MEDIUM CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	19.600	19.700	0.100	0.510
1977	20.720	20.620	-0.100	0.483
1978	22.580	22.580	0.0	0.0
1979	22.540	22.840	0.300	1.331
1980	24.599	24.999	0.400	1.626
1981	24.799	24.699	-0.100	0.403
1982	24.899	24.799	-0.100	0.402
1983	24.599	24.899	0.300	1.219
1984	24.699	24.999	0.300	1.214
1985	25.599	24.599	-1.000	3.906

TABLE F-78
LARGE CAR FUEL ECONOMY

YEAR	CONTROL	SHOCK	DIFFERENCE	% DIFF
1976	16.590	16.590	0.0	0.0
1977	17.690	17.690	0.0	0.0
1978	17.590	17.690	0.100	0.568
1979	18.590	18.690	0.100	0.538
1980	19.590	19.790	0.200	1.021
1981	20.510	20.510	0.0	0.0
1982	19.530	20.630	1.100	5.632
1983	20.550	20.550	0.0	0.0
1984	20.770	20.770	0.0	0.0
1985	20.690	20.590	-0.100	0.483

APPENDIX G

FAUCETT MODEL PROGRAM LISTING: 8/77 VERSION

```
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      COMMON/BLOCK3/OPNEW(3),OPCEST(26),OPCLAS(3,26),NEW(3,26)
      COMMON/BLOCK4/GAS(26),PUSED(26),SALES(26),PRICE(26),
     1 GPRICE(3,26)
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1 SCRAP(3,26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON TT(1),IS
      DIMENSION ANM(20),JJGAS(5), AP(26)
      DIMENSION IZERO(26),IMAXR(26)
      DIMENSION TKPCAR(3,4)
      DIMENSION ACCT(30,26)
      DIMENSION KYEAR(26),PYTB(26,2),SHNEW(3),CST(3),FEC(3)
      DIMENSION DRI(26), TRBSGS(26)
      DIMENSION GASTOT(26), CARDSL(26), TRDSL(26), DIESEL(26)
      INTEGER EXTX(40,26)
      INTEGER T,TT,C,Q
      DATA BOTH/4HBOTH/
      DATA SETX/4HSETX/
      DATA EXCI/4HEXCI/
      DATA STAN/4HSTAN/
      DATA YES/4HYES /
      DATA DRI/1.0,0.69,.86,.91,.95,.97,1.01,
     1 1.03,1.02,1.02,6*1.03,10*1.03/
      DATA DIESEL /0.,0.,0.,.0015, .0040, .0075, .0125,
     1 .0225, .0375, .0575, .0825, .1125, .1425, .1725,
     2 .2025, .2325, 10*.30/
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET,QFLEET,TDRI,TSALES
      REAL NEW,NFUELE,MILES,INCOME
C     *         *****************
  501 FORMAT(' YEAR               ',5I11)
  502 FORMAT(' TOTAL SALES        ',5F11.0)
  503 FORMAT('    SMALL SHARE     ',5F11.3)
  504 FORMAT('    MEDIUM SHARE    ',5F11.3)
  505 FORMAT('    LARGE SHARE     ',5F11.3)
  506 FORMAT(' CARS IN USE        ',5F11.0)
  507 FORMAT('    SMALL SHARE     ',5F11.3)
  508 FORMAT('    MEDIUM SHARE    ',5F11.3)
  509 FORMAT('    LARGE SHARE     ',5F11.3)
  510 FORMAT(' SCRAPPAGE          ',5F11.0)
  511 FORMAT(1H1,20A4)
  512 FORMAT(20A4)
  513 FORMAT (1X,I5,3F11.0)
  514 FORMAT(' USED PRICE         ',5F11.3)
  515 FORMAT(' GAS PRICE          ',5F11.3)
  516 FORMAT(' VMT                ',5F11.0)
  517 FORMAT(' CAR GAS CONSUMED   ',5F11.0)
  518 FORMAT(' FLEET MPG          ',5F11.3)
  519 FORMAT(' AVG. GEN. PRICE    ',5F11.0)
  520 FORMAT(' AVG. NEW CAR MPG   ',5F11.3)
  521 FORMAT('    SMALL MPG       ',5F11.3)
  522 FORMAT('    MEDIUM MPG      ',5F11.3)
  523 FORMAT('    LARGE MPG       ',5F11.3)
  525 FORMAT(1X)
  526 FORMAT (' DO YOU WANT THE SECONDARY OUTPUT? ENTER YES OR NO :')
  527 FORMAT (' TRUCK GAS          ',5F11.0)
  528 FORMAT (' CAR DIESEL         ',5F11.0)
  529 FORMAT (' TRUCK DIESEL       ',5F11.0)
  530 FORMAT(3A4)
  531 FORMAT(/////30X,' EXCISE TAX TABLE'//)
  532 FORMAT(I8,13I5)
  533 FORMAT(////'    YEAR',14I5)
  535 FORMAT(///////////////)
  536 FORMAT(' TOTAL GAS CONSMP ',5F11.0)
  537 FORMAT(' TOTAL DIESEL     ',5F11.0)
  538 FORMAT(' TOTAL GAS (MBL)  ',5F11.3)
  539 FORMAT(' TOTAL GAS (QUADS)',5F11.3)
  540 FORMAT('    DIESEL  (MBL) ',5F11.3)
  541 FORMAT('    DIESEL  (QUADS)',5F11.3)
  542 FORMAT(' PLEASE TYPE RUN IDENTIFICATION')
  543 FORMAT (' YEAR        AUTO        NEW CAR   GASOLINE  DIESEL',
     1 '     GASOLINE  ',/
     2        '             SALES       SALES WTD   - AUTO  FUEL-AUTO',
     3 '   TOTAL',/
     4        '             (UNITS)     FUEL ECON  (MBL/D)    (MBL/D)',
     5' (MBL/D)',/
     6        '                         (MPG)',/)
  544 FORMAT (1X,I10,F10.0,4F10.3)
  560 FORMAT(1H1,////)
  561 FORMAT(//)
  563 FORMAT(F3.0)
  564 FORMAT(F2.0)
  565 FORMAT(' DO YOU WISH TO PRINT EXCISE TAX TABLE?')
  570 FORMAT(' FINANCIAL IMPACTS:')
  571 FORMAT(' TAX/REBATE:SMALL ',5F11.3)
  572 FORMAT(' TAX/REBATE: MED. ',5F11.3)
  573 FORMAT(' TAX/REBATE:LARGE ',5F11.3)
  574 FORMAT(' TOTAL EX. TAXES  ',5F11.3)
  575 FORMAT(' TOTAL REBATES    ',5F11.3)
  576 FORMAT(' NET TAX/REBATE   ',5F11.3)
  577 FORMAT(' PENALTIES: SMALL ',5F11.3)
  578 FORMAT(' PENALTIES:  MED. ',5F11.3)
  579 FORMAT(' PENALTIES: LARGE ',5F11.3)
  580 FORMAT(' TOTAL PENALTIES  ',5F11.3)
  581 FORMAT(' PRICE ANALYSIS'/'  SMALL CARS')
  582 FORMAT('    BASE PRICE     ',5F11.0)
  583 FORMAT('    TECH. ADD-ONS  ',5F11.0)
  584 FORMAT('    POLICY ADD-ONS ',5F11.0)
  585 FORMAT('    NET CAR PRICE  ',5F11.0)
  586 FORMAT('  MEDIUM CARS')
  587 FORMAT('    BASE PRICE     ',5F11.0)
  588 FORMAT('    TECH. ADD-ONS  ',5F11.0)
  589 FORMAT('    POLICY ADD-ONS ',5F11.0)
  590 FORMAT('    NET CAR PRICE  ',5F11.0)
  591 FORMAT('  LARGE CARS')
  592 FORMAT('    BASE PRICE     ',5F11.0)
  593 FORMAT('    TECH. ADD-ONS  ',5F11.0)
  594 FORMAT('    POLICY ADD-ONS ',5F11.0)
  595 FORMAT('    NET CAR PRICE  ',5F11.0)
  596 FORMAT(' MPG OF ZERO TAX  ',5F11.0)
  597 FORMAT(' MPG OF MAX REBATE',5F11.0)
  598 FORMAT(' PLEASE SET PRINTER TO RECEIVE OUTPUT(OPTIONAL)')
  599 FORMAT(//////)
  605 FORMAT(2X,5F5.2)
  606 FORMAT(2X,3F6.3,2(1X,3F6.3))
```

```
  608 FORMAT(' MAXIMUM REBATE   ',5F11.0)
  609 FORMAT(' EXCISE TAX SCHEDULE')
      DO 99 I = 1,26
      CARDSL(I) = 0.
      TRDSL(I) = 0.
      GASTOT(I) = 0.
 99   CONTINUE
      IS=14
      NL=26
      N = 15
      IP=1975
      IYEAR = 1
      WRITE(15,542)
      READ (5,512)(ANM(L),L=1,18)
      JJ=1
      CALL POLICY(PYTB,EXTX,APOL,IZERO,IMAXR,N,MPGGPM)
      T=2
      OPCARS(1)=0.
      DO 100 C=1,3
      DO 100 M=1,IS
  100 OPCARS(1)=OPCARS(1)+FLEET(C,M)
      NEW(1,1)=.2500
      NEW(2,1)=.2450
      NEW(3,1)=.5050
      ECON(1,1)=22.3
      ECON(2,1)=15.3
      ECON(3,1)=12.6
      PCAR(1,1)=3000/1.477
      PCAR(2,1)=3598/1.477
      PCAR(3,1)=4654/1.477
      A=0.
      DO 105 C=1,3
      PRICE(1)=A+PCAR(C,1)*NEW(C,1)
      A=PRICE(1)
  105 CONTINUE
      DO 110 C=1,3
  110 OPNEW(C)=PGAS(1)/ECON(C,1)
C     * COMPUTE THE MARKET WEIGHTED AVERAGE NOW
      OPCEST(1)=0.0
      DO 115 C=1,3
      GPRICE(C,1)=PCAR(C,1)+(52853./ECON(C,1)*PGAS(1))
      A=OPCEST(1)
  115 OPCEST(1)=A+NEW(C,1)*OPNEW(C)
      APRICE(1)=OPCEST(1)*52853+PRICE(1)
      JJ=1
      NXX=N+1
      DO 130 KKM=2,NXX
      TT(1)=KKM
      T=TT(1)
      QQQ=PGAS(T)*1.477
      SHNEW(1)=NEW(1,T-1)
      SHNEW(2)=NEW(2,T-1)
      SHNEW(3)=NEW(3,T-1)
      CALL SETPR(T,QQQ,PYTB,EXTX,SHNEW,APOL,CST,FEC,IMAXR,IZERO,
     + ACCT,MPGGPM)
      DO 120 C=1,3
      PCAR(C,T)=CST(C)/1.612
  120 ECON(C,T)=FEC(C)
      CALL RETIRE
      CALL TOTAL
      CALL SHARE
      SALES(KKM) = SALES(KKM)*DRI(KKM)
      CALL VMTS
      CALL GASCON
  130 CONTINUE
      NVZ=N+1
      DO 150 I=2,NVZ
      ACCT(7,I)=ACCT(7,I)*1.612*SALES(I)
      PGAS(I)=PGAS(I)*1.477
      APRICE(I)=APRICE(I)*1.612
      GAS(I)=GAS(I)*1.14
      DO 135 J=1,3
      MEM=ECON(J,I)+0.5
      ACCT(J,I)=NEW(J,I)*SALES(I)*EXTX(MEM,I-1)
      ACCT(J+3,I)=ACCT(J+3,I)*NEW(J,I)*SALES(I)
      PCAR(J,I)=PCAR(J,I)*1.612
  135 GPRICE(J,I)=GPRICE(J,I)*1.612
      DO 140 IJ=1,7
  140 ACCT(IJ,I)=ACCT(IJ,I)/ 1000000.
      ACCT(21,I)=0.0
      ACCT(22,I)=0.0
      ACCT(20,I)=0.0
      DO 145 IJ=1,3
      IF(ACCT(IJ,I).GT.0.0) ACCT(20,I)=ACCT(20,I)+ACCT(IJ,I)
      IF(ACCT(IJ,I).LT.0.0) ACCT(21,I)=ACCT(21,I)+ACCT(IJ,I)
  145 ACCT(22,I)=ACCT(22,I)+ACCT(IJ,I)
  150 CONTINUE
      WRITE(15,598)
      READ(5,525)
      WRITE(15,560)
      JJ=((IP+1)/IYEAR)*IYEAR-IP-1+IYEAR
      IF(JJ.EQ.IYEAR) JJ=0
      DO 155 LY=1,26
  155 KYEAR(LY)=IP+LY-1
      LY=0
      L3=IYEAR
      GO TO 160
  165 WRITE(15,599)
  160 LY=LY+1
      L1=JJ+2+(LY-1)*IYEAR*5
      IF(L1.GT.NXX) GO TO 200
      L2=L1+4*IYEAR
      IF (L2.LE.NXX) GO TO 170
      L2=NXX
  170 CONTINUE
      WRITE(15,511) (ANM(L),L=1,18)
      WRITE(15,561)
      WRITE(15,501) (KYEAR(L),L=L1,L2,L3)
      WRITE(15,502) (SALES(L),L=L1,L2,L3)
      WRITE(15,503) (NEW(1,L),L=L1,L2,L3)
      WRITE(15,504) (NEW(2,L),L=L1,L2,L3)
      WRITE(15,505) (NEW(3,L),L=L1,L2,L3)
      WRITE(15,520) (FFUEL(L),L=L1,L2,L3)
      WRITE(15,521) (ECON(1,L),L=L1,L2,L3)
      WRITE(15,522) (ECON(2,L),L=L1,L2,L3)
      WRITE(15,523) (ECON(3,L),L=L1,L2,L3)
      WRITE(15,506) (OPCARS(L),L=L1,L2,L3)
      WRITE(15,507) (OPCLAS(1,L),L=L1,L2,L3)
      WRITE(15,508) (OPCLAS(2,L),L=L1,L2,L3)
      WRITE(15,509) (OPCLAS(3,L),L=L1,L2,L3)
```

```
      WRITE(15,510)  (TSCRAP(L),L=L1,L2,L3)
      WRITE(15,515)  (PGAS(L),L=L1,L2,L3)
      WRITE(15,516)  (VMT(L),L=L1,L2,L3)
      WRITE(15,517)  (GAS(L),L=L1,L2,L3)
      WRITE(15,519)  (APRICE(L),L=L1,L2,L3)
      IF(APOL.EQ.STAN) GO TO 180
      IF(APOL.EQ.BOTH) GO TO 175
      IF(APOL.EQ.EXCI) GO TO 175
      IF(APOL.EQ.SETX) GO TO 175
      GO TO 185
  175 WRITE(15,570)
      WRITE(15,571)  (ACCT(1,L),L=L1,L2,L3)
      WRITE(15,572)  (ACCT(2,L),L=L1,L2,L3)
      WRITE(15,573)  (ACCT(3,L),L=L1,L2,L3)
      WRITE(15,574)  (ACCT(20,L),L=L1,L2,L3)
      WRITE(15,575)  (ACCT(21,L),L=L1,L2,L3)
      WRITE(15,576)  (ACCT(22,L),L=L1,L2,L3)
      IF(APOL.EQ.EXCI) GO TO 185
  180 WRITE(15,580)  (ACCT(7,L),L=L1,L2,L3)
  185 WRITE(15,581)
      WRITE(15,582)  (ACCT(8,L),L=L1,L2,L3)
      WRITE(15,583)  (ACCT(9,L),L=L1,L2,L3)
      WRITE(15,584)  (ACCT(10,L),L=L1,L2,L3)
      WRITE(15,585)  (PCAR(1,L),L=L1,L2,L3)
      WRITE(15,586)
      WRITE(15,587)  (ACCT(11,L),L=L1,L2,L3)
      WRITE(15,588)  (ACCT(12,L),L=L1,L2,L3)
      WRITE(15,589)  (ACCT(13,L),L=L1,L2,L3)
      WRITE(15,590)  (PCAR(2,L),L=L1,L2,L3)
      WRITE(15,591)
      WRITE(15,592)  (ACCT(14,L),L=L1,L2,L3)
      WRITE(15,593)  (ACCT(15,L),L=L1,L2,L3)
      WRITE(15,594)  (ACCT(16,L),L=L1,L2,L3)
      WRITE(15,595)  (PCAR(3,L),L=L1,L2,L3)
      IF (APOL.EQ.SETX) GO TO 190
      GO TO 195
  190 WRITE(15,609)
      WRITE(15,596)  (ACCT(17,L),L=L1,L2,L3)
      WRITE(15,597)  (ACCT(18,L),L=L1,L2,L3)
      WRITE(15,608)  (ACCT(19,L),L=L1,L2,L3)
  195 CONTINUE
      IF(L2.GE.N) GO TO 200
      GO TO 165
  200 WRITE(15,535)
      IF(APOL.EQ.EXCI) GO TO 205
      IF(APOL.EQ.SETX) GO TO 205
      IF(APOL.EQ.BOTH) GO TO 205
      GO TO 230
  205 WRITE(15,565)
      READ(5,530) AA
      IF(AA.NE.YES) GO TO 230
      WRITE(15,531)
      WRITE(15,533)(M,M=1,13)
      DO 210 I=1,N
      IYR=I+1975
  210 WRITE(15,532)IYR,(EXTX(MM,I),MM=1,13)
      WRITE(15,533)(M,M=14,26)
      DO 220 I=1,N
      IYR=I+1975
  220 WRITE(15,532)IYR,(EXTX(MM,I),MM=14,26)
```

```
      WRITE(15,533)(M,M=27,39)
      DO 225 I=1,N
      IYR=I+1975
  225 WRITE(15,532)IYR,(EXTX(MM,I),MM=27,39)
  230 CONTINUE
  235 CONTINUE
  999 STOP
      END
```

```
      SUBROUTINE RETIRE
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      COMMON/BLOCK4/GAS(26),PUSED(26),SALES(26),PRICE(26),
     1GPRICE(3,26)
      COMMON/BLOCK3/OPNEW(3),OPCEST(26),OPCLAS(3,26),NEW(3,26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1SCRAP(3,26)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON TT(1),IS
      DIMENSION BASEP(3)
      REAL NEW,NFUELE,MILES,INCOME
      DOUBLE PRECISION B,D,SPG
      INTEGER T,TT,C
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET
      T=TT(1)
      BASEP(1)=2412.
      BASEP(2)=2917.
      BASEP(3)=3901.
      DO 26 C=1,3
      DO 27 M=1,IS
      IF(M.GE.9) GO TO 30
      SCRAP(C,M)=FLEET(C,M)*SRATE(M)
      GO TO 31
   30 SPG=0.40675-0.015519*UNEMPR(T)
      SPG=(SPG-0.078433*PCAR(C,T)/BASEP(C))/0.2481
      SCRAP(C,M)=FLEET(C,M)*SRATE(M)*SPG
   31 RFLEET(C,M)=FLEET(C,M)-SCRAP(C,M)
      NFUELE(C,M)=FUELEC(C,M)
   27 CONTINUE
   26 CONTINUE
      DO 39 C=1,3
      B=RFLEET(C,IS)+RFLEET(C,IS-1)
      D=RFLEET(C,IS)/FUELEC(C,IS)+RFLEET(C,IS-1)/FUELEC(C,IS-1)
      FUELEC(C,IS)=B/D
      FLEET(C,IS)=B
      FUELEC(C,1)=ECON(C,T)
   39 CONTINUE
      DO 28 C=1,3
      JJ=IS-2
      DO 28 M=1,JJ
      K=M+1
      FLEET(C,K)=RFLEET(C,M)
      FUELEC(C,K)=NFUELE(C,M)
   28 CONTINUE
      RETURN
      END
```

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      SUBROUTINE TOTAL
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```
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1SCRAP(3,26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(3,26)
      COMMON/BLOCK3/OPNEW(3),OPCEST(26),OPCLAS(3,26),NEW(3,26)
      COMMON/BLOCK4/GAS(26),PUSED(26),SALES(26),PRICE(26),
     1GPRICE(3,26)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      COMMON TT(1)
      REAL NEW,NFUELE,MILES,INCOME
      INTEGER T,TT,C
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1 FLEET
      T=TT(1)
      PRICE(T)=0.
      DO 34 C=1,3
      PRICE(T)=PRICE(T)+PCAR(C,T)*NEW(C,T-1)
      OPNEW(C)=PGAS(T)/ECON(C,T)
   34 CONTINUE
      OPCEST(T)=0.
      DO 35 C=1,3
      OPCEST(T)=OPCEST(T)+NEW(C,T-1)*OPNEW(C)
   35 CONTINUE
      APRICE(T)=PRICE(T)+52853*OPCEST(T)
      A=0.00002765*((APRICE(T)/4564.0)**2.1626)
      B=DISINC(T)**1.1512
      PUSED(T)=A*B
      RETURN
      END
      SUBROUTINE SHARE
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1SCRAP(3,26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK4/GAS(26),PUSED(26),SALES(26),PRICE(26),
     1GPRICE(3,26)
      COMMON/BLOCK3/OPNEW(3),OPCEST(26),OPCLAS(3,26),NEW(3,26)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      COMMON TT(1),IS
      REAL NDUMMY(3,26)
      INTEGER T,TT,C
      REAL NEW,NFUELE,MILES,INCOME
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET
      DOUBLE PRECISION EX,A,B
      T=TT(1)
  546 FORMAT(' NEW CAR DEMAND SATURATED')
  571 FORMAT(1X,I4)
      DO 36 C=1,3
   36 GPRICE(C,T)=PCAR(C,T)+(52853./ECON(C,T)*PGAS(T))
       GPRICE(1,T)=GPRICE(1,T)*3010./GPRICE(1,1)
      GPRICE(2,T)=GPRICE(2,T)*3863./GPRICE(2,1)
      GPRICE(3,T)=GPRICE(3,T)*4883./GPRICE(3,1)
      ZPRC=APRICE(T)
      APRICE(T)=APRICE(1)
      A=4.1749+1.8666*1.3898*GPRICE(1,T)/APRICE(T)
      B=(-3.5093*1.0966*GPRICE(2,T))/APRICE(T)
      D=-5.6428*((NEW(1,T-1)+NEW(1,1))*0.5)
      NEW(1,T)=1.0/(1.0+2.7183**(A+B+D))
      A=4.1749+2.0765*1.0966*GPRICE(2,T)/APRICE(T)
      B=-3.545*1.3898*GPRICE(1,T)/APRICE(T)
      B=B-0.2589*0.8181*GPRICE(3,T)/APRICE(T)
      D=-5.6428*((NEW(2,T-1)+NEW(2,1))*0.5)
      NEW(2,T)=1.0/(1.0+2.7183**(A+B+D))
      A=4.1749+0.4299*0.8181*GPRICE(3,T)/APRICE(T)
      B=-1.8117*1.0966*GPRICE(2,T)/APRICE(T)
      D=-5.6428*((NEW(3,T-1)+NEW(3,1))*0.5)
      NEW(3,T)=1.0/(1.0+2.7183**(A+B+D))
      SUMNEW=0.0
      APRICE(T)=0.0
      DO 37 C=1,3
      GPRICE(C,T)=PCAR(C,T)+52853.*PGAS(T)/ECON(C,T)
      B=SUMNEW
      SUMNEW=B+NEW(C,T)
   37 CONTINUE
      NEW(3,T)=0.8*NEW(3,T)+0.2*NEW(3,T)/SUMNEW
      NEW(2,T)=(NEW(2,T)/(NEW(1,T)+NEW(2,T)))*(1.-NEW(3,T))
      NEW(1,T)=1.-NEW(3,T)-NEW(2,T)
      DO 38 C=1,3
      APRICE(T)=APRICE(T)+NEW(C,T)*GPRICE(C,T)
   38 CONTINUE
      TSCRAP(T)=0.
      DO 39 C=1,3
      DO 39 M=1,IS
      TSCRAP(T)=TSCRAP(T)+SCRAP(C,M)
   39 CONTINUE
      EX=TARGET(T)+TSCRAP(T)-OPCARS(T-1)
      IF (EX.LT.0.0) GOTO 145
      A=(EX**0.2178)*286721.3
      B=((4564./APRICE(T))*(APRICE(1)/4059.))**1.70387
      SALES(T)=A*B
  145 IF(EX.GE.0.0) GO TO 146
      WRITE(15,546)
      IYR=1975 + T-1
      WRITE(15,571)IYR
      SALES(T)=1.0
  146 JJ=1
      DO 40 C=1,3
   40 FLEET(C,1)=NEW(C,T)*SALES(T)
      RETURN
      END
      SUBROUTINE VMTS
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      COMMON/BLOCK3/OPNEW(3),OPCEST(26),OPCLAS(3,26),NEW(3,26)
      COMMON/BLOCK4/GAS(26),PUSED(26),SALES(26),PRICE(26),
     1GPRICE(3,26)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1SCRAP(3,26)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      COMMON TT(1),IS
```

```
      REAL NEW,NFUELE,MILES, INCOME
      REAL K2,KSUM,KSUM2
      INTEGER T,TT,C
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET
      T=TT(1)
      KSUM=0.
      OPCARS(T)=0.
      DO 39 C=1,3
      OPCLAS(C,T)=0.0
      DO 39 M=1,IS
      OPCLAS(C,T)=OPCLAS(C,T)+FLEET(C,M)
      OPCARS(T)=OPCARS(T)+FLEET(C,M)
      K2=KSUM
      KSUM=K2+(FLEET(C,M)/FUELEC(C,M))
   39 CONTINUE
      OPCALL(T)=KSUM*PGAS(T)/OPCARS(T)
      DO 40 C=1,3
   40 OPCLAS(C,T)=OPCLAS(C,T)/OPCARS(T)
      A=-52979.8+15087.*ALOG10(DISINC(T))-2204.24*ALOG10(OPCALL(T)
     1 *100.)
      VMT(T)=A*POP(T)+6337.68*OPCARS(T)
      VMT(T)=VMT(T)*0.000001
      RETURN
      END
      SUBROUTINE GASCON
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      COMMON/BLOCK3/OPNEW(3),OPCEST(26),OPCLAS(3,26),NEW(3,26)
      COMMON/BLOCK4/GAS(26),PUSED(26),SALES(26),PRICE(26),
     1GPRICE(3,26)
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1SCRAP(3,26)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      COMMON TT(1),IS
      REAL K,MILES,NUMER,KMILES,J
      REAL NEW,NFUELE,MILES, INCOME
      INTEGER T,TT,C
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET
      DIMENSION NUMER(20),DENOM(20)
      T=TT(1)
      JJ=IS-1
      DO 40 M=1,JJ
      J=M
      PMILES=0.
      DO 40 C=1,3
      KMILES=FLEET(C,M)*(17.9729-(9.57841*ALOG10(J)))
      MILES(M)=PMILES+KMILES
      PMILES=MILES(M)
   40 CONTINUE
      PMILES=0.
      DO 41 C=1,3
      KMILES=FLEET(C,IS)*(17.9729-(9.57481*ALOG10(15.0)))
      MILES(IS)=PMILES+KMILES
      PMILES=MILES(IS)
   41 CONTINUE
      TOTMI=0.0
      DO 42 M=1,IS
   42 TOTMI=TOTMI+MILES(M)
      A=TOTMI
      TOTMI=VMT(T)/A
      DO 43 M=1,IS
   43 MILES(M)=MILES(M)*TOTMI
      DO 44 M=1,IS
      NUMER(M)=0.0
      DENOM(M)=0.
      DO 44 C=1,3
      IA=NUMER(M)
      B=DENOM(M)
      NUMER(M)=IA+FLEET(C,M)
      DENOM(M)=B+(FLEET(C,M)/FUELEC(C,M))
   44 CONTINUE
      GAS(T)=0.
      DO 45 M=1,IS
      FECON(M)=NUMER(M)/DENOM(M)
      B=GAS(T)
      GAS(T)=B+(MILES(M)/FECON(M))
   45 CONTINUE
      FFUEL(T)=0.0
      DO 48 C=1,3
   48 FFUEL(T)=FFUEL(T)+NEW(C,T)/ECON(C,T)
      FFUEL(T)=1./FFUEL(T)
      RETURN
      END
      SUBROUTINE POLICY(PYTB,EXTX,APOL,IZERO,IMAXR,NUMRY,
     + MPGGPM)
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      DIMENSION PYTB(26,2),PR(3),EC(3)
      DIMENSION IZERO(26),IMAXR(26)
      INTEGER EXTX(40,26)
      REAL INCOME
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET
  565 FORMAT(I4)
  554 FORMAT(' DO YOU WISH TO CHECK INPUT FOR STANDARDS?')
  555 FORMAT(///'     YEAR STANDARD PENALTY')
  556 FORMAT(' DO YOU WISH TO CHANGE INPUT FOR STANDARDS?')
  557 FORMAT(' ARE GASOLINE PRICE INPUTS CHANGING AT A CONSTANT',
     1' GROWTH RATE?')
  558 FORMAT(' INPUT 1976 GASOLINE PRICE AND GROWTH RATE')
  559 FORMAT(' INPUT GASOLINE PRICES STARTING WITH 1976')
  566 FORMAT(I2,1X,I2)
  500 FORMAT (3A4)
  501 FORMAT(////'     YEAR',14I5)
  502 FORMAT (I8,13I5)
  505 FORMAT (I8,2F8.2)
  545 FORMAT(' PLEASE SPECIFY POLICY')
  580 FORMAT(' INPUT YEAR AND NEW CAR PRICES,SMALL,MEDIUM,AND ',
     1'LARGE'/' STARTING WITH 1975')
  581 FORMAT(' INPUT YEAR AND NEW CAR FUEL ECONOMIES,SMALL,',
     1'MEDIUM,AND LARGE'/' STARTING WITH 1975')
  582 FORMAT(' DO YOU WISH TO CHECK INPUT PRICES AND FUEL ',
     1'ECONOMIES')
  583 FORMAT(' DO YOU WISH TO CHANGE INPUT PRICES OR FUEL ',
     1'ECONOMIES')
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  585 FORMAT(I4,1X,F5.0,1X,F5.0,1X,F5.0)
  586 FORMAT(I4,1X,F5.2,1X,F5.2,1X,F5.2)
  587 FORMAT('                    NEW CAR PRICES            NEW CAR FUEL
     1' ECONOMIES'//'                    YEAR SMALL  MED  LARGE
     2'YEAR SMALL  MED  LARGE')
  588 FORMAT(3X,I11,3(1X,F5.0),I10,3(1X,F5.2))
  547 FORMAT(' YEAR')
 548  FORMAT(' RANGE')
 549  FORMAT(' EXCISE TAX ENTRIES')
 550  FORMAT(' DO YOU WISH TO CHECK EXCISE TAX INPUT?')
 551  FORMAT(' PLEASE SPECIFY MPG RANGE')
 552  FORMAT(' DO YOU WISH TO CHANGE EXCISE TAX INPUT?')
 553  FORMAT(' PLEASE INPUT YEAR, STANDARD, AND PENALTY')
  590 FORMAT(' PLEASE INPUT PARAMETERS FOR REBATE COMPUTATION')
  591 FORMAT(' STARTING YEAR, ENDING YEAR, ZERO POINT, MAX. MPG')
  592 FORMAT(' INPUT FORMAT: XXXX,XXXX,XX.X,XX')
  593 FORMAT(I4,1X,I4,1X,F4.1,1X,I2)
  595 FORMAT(' ARE EXCISE TAX INPUTS IN GALLONS PER MILE?')
  597 FORMAT(' START,END,ZERO POINT,MIN MPG,MAX MPG,MPG VALUE'
     1 ',REBATE?',/
     +' INPUT FORMAT: XXXX,XXXX,XX.X,XX,XX.X,XXX,XX')
  598 FORMAT(' ARE REBATES TO BE IN TERMS OF GAL./MI.?')
  599 FORMAT(I4,1X,I4,1X,F4.1,1X,I2,1X,F4.1,1X,I3,1X,A2)
  5   WRITE(15,545)
  531 FORMAT(' DESCRIPTION OF STANDARDS')
  532 FORMAT(' DESCRIPTION OF EXCISE TAXES')
      DATA RNONE/4HNONE/
      DATA EXCI/4HEXCI/
      DATA STAN/4HSTAN/
      DATA YES/4HYES /
      DATA RNO/4HNO  /, NO/4HNO  /
      DATA EXOG/4HEXOG/
      DATA BOTH/4HBOTH/
      DATA SETX/4HSETX/
 568  FORMAT(I4,1X,F5.2,1X,F5.0)
 569  FORMAT(F5.2,1X,F3.0)
 570  FORMAT(F5.2)
  571 FORMAT(14(I4,1X))
  572 FORMAT(14(I4,1X)/14(I4,1X))
  573 FORMAT(14(I4,1X)/14(I4,1X)/14(I4,1X))
      READ (5,500)APOL
      IF(APOL.EQ. RNONE) GO TO 99
      IF(APOL.EQ. EXCI) GO TO 20
      IF(APOL.EQ. STAN) GO TO 50
      IF(APOL.EQ. EXOG) GO TO 90
      IF(APOL.EQ. BOTH) GO TO 20
      IF(APOL.EQ.SETX) GO TO 800
      GO TO 5
  800 WRITE(15,590)
      WRITE(15,591)
      WRITE(15,592)
  802 READ(5,593) IYR1,IYR2,Z,IM
      IF(IYR1.EQ.0) GO TO 810
      I1=IYR1-1974
      I2=IYR2-1974
      DO 805 I=I1,I2
      IZERO(I)=Z
  805 IMAXR(I)=IM
      GO TO 802
  810 WRITE(15,598)
      MPGGPM=0
      READ(5,500) AA
      IF(AA.EQ.YES) MPGGPM=1
      GO TO 20
   20 IMAX=1
      WRITE(15,532)
      DO 21 M=1,40
      DO 21 I=1,26
   21 EXTX(M,I)=0
  215 WRITE(15,595)
      READ(5,500) AA
      IF(AA.EQ.RNO) GO TO 22
      IF(AA.EQ.YES) GO TO 210
      GO TO 215
  210 WRITE(15,597)
  220 READ(5,599) IYR1,IYR2,ZM,MMIN,RMAX,IVAL,NORBT
      MMAX=RMAX
      IF(IYR1.EQ.0) GO TO 27
      IF(ZM.EQ.0.0) GO TO 210
      I1=IYR1-1974
      I2=IYR2-1974
      VAL=IVAL
      VAL=VAL/((1./(ZM-0.5))-(1./(ZM+0.5)))
      DO 225 I=I1,I2
      DO 224 M=MMIN,MMAX
  224 EXTX(M,I-1)=(1./M-1./ZM)*VAL
      EMIN=(1./MMIN-1./ZM)*VAL
      DO 223 M=1,MMIN
  223 EXTX(M,I-1)=EMIN
      EMAX=(1./RMAX-1./ZM)*VAL
      IF ((EMAX .LE. 0.) .AND. (NORBT .EQ. NO)) EMAX = 0.
      DO 222 M=MMAX,40
  222 EXTX(M,I-1)=EMAX
  225 CONTINUE
      GO TO 220
   22 WRITE(15,547)
      READ(5,565)IYR
      IF(IYR.EQ.0) GOTO 23
      LIM=IYR-1975
      IF(LIM.GT.IMAX) IMAX=LIM
      WRITE(15,548)
      READ(5,566)M1,M2
      M3=M2-M1+1
      IF(M1.LT.1) GO TO 22
      IF(M2.GT.40) GO TO 22
      WRITE(15,549)
      IF(M3.GT.14) GO TO 80
      READ(5,571)(EXTX(M,LIM),M=M1,M2)
      GO TO 85
   80 IF(M3.GT.28) GO TO 81
      READ(5,572)(EXTX(M,LIM),M=M1,M2)
      GO TO 85
   81 READ(5,573)(EXTX(M,LIM),M=M1,M2)
   85 CONTINUE
      DO 24 MM=1,M1
   24 EXTX(MM,LIM)=EXTX(M1,LIM)
      DO 25 MM=M2,40
   25 EXTX(MM,LIM)=EXTX(M2,LIM)
      GO TO 22
   23 DO 28 I=IMAX,26
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      DO 28 M=1,40
   28 EXTX(M,I)=EXTX(M,IMAX)
   27 WRITE(15,550)
      READ (5,500)AA
      IF(AA.EQ. RNO  ) GO TO 29
      IF(AA.EQ. YES ) GO TO 34
      GO TO 27
   34 WRITE(15,551)
      READ(5,566)M1,M2
      M3=M2-M1
      IF(M3.GT.13) GO TO 30
      WRITE(15,501)(M,M=M1,M2)
      DO 31 I=1,NUMRY
      IYR=I+1975
   31 WRITE(15,502)IYR,(EXTX(MM,I),MM=M1,M2)
   29 WRITE(15,552)
      READ (5,500)AA
      IF(AA.EQ. YES ) GO TO 215
      IF(APOL.EQ. BOTH)GO TO 50
      IF(APOL.EQ. SETX)GO TO 50
      IF(AA.EQ. RNO  ) GO TO 99
      GO TO 29
   30 WRITE(15,501)(M,M=1,13)
      DO 36 I=1,25
      IYR=I+1975
   36 WRITE(15,502)IYR,(EXTX(MM,I),MM=1,13)
      WRITE(15,501)(M,M=14,26)
      DO 37 I=1,25
      IYR=I+1975
   37 WRITE(15,502)IYR,(EXTX(MM,I),MM=14,26)
      IF(M2.LT.27) GO TO 29
      WRITE(15,501)(M,M=27,39)
      DO 38 I=1,25
      IYR=I+1975
   38 WRITE(15,502) IYR,(EXTX(MM,I),MM=27,39)
      WRITE(15,501)(M,M=40,40)
      DO 39 I=1,25
      IYR=I+1975
   39 WRITE(15,502)IYR,(EXTX(MM,I),MM=40,40)
      GO TO 29
   50 IMAX=1
      WRITE(15,531)
      IMIN=26
   49 WRITE(15,553)
   52 READ(5,568)IYR,STD,PY
      IF(IYR.EQ.0) GO TO 60
      LIM=IYR-1974
      IF(LIM.GT.IMAX) IMAX=LIM
      IF(LIM.LT.IMIN) IMIN=LIM-1
      PYTB(LIM,1)=STD
      PYTB(LIM,2)=PY
      GO TO 52
   60 IXP=IMIN-1
      IF(IMAX.EQ.1) GO TO 700
      IF(IXP.LT.1) IXP=1
      DO 55 I=1,IMIN
      PYTB(I,1)=0
   55 PYTB(I,2)=0
      DO 56 I=IMAX,26
      PYTB(I,1)=PYTB(IMAX,1)
   56 PYTB(I,2)=PYTB(IMAX,2)
   61 WRITE(15,554)
      READ (5,500)AA
      IF(AA.EQ. YES ) GO TO 63
      IF(AA.EQ. RNO  ) GO TO 70
      GO TO 61
   63 WRITE(15,555)
      NUMYR=NUMRY+1
      DO 65 I=1,NUMYR
      IYR=I+1974
   65 WRITE(15,505)IYR,PYTB(I,1),PYTB(I,2)
   70 WRITE(15,556)
      READ (5,500)AA
      IF(AA.EQ. YES ) GO TO 49
      IF(AA.EQ. RNO  ) GO TO 99
      GO TO 70
  700 DO 701 I =1,3
      PYTB(I,1)=0
  701 PYTB(I,2)=0
      PYTB(4,1)=18.
      PYTB(5,1)=19.
      PYTB(6,1)=20.
      PYTB(7,1)=21.5
      PYTB (8,1)=23.
      PYTB(9,1)=24.5
      PYTB(10,1)=26.
      PYTB(11,1)=27.5
      DO 702 I=4,11
  702 PYTB(I,2)=100.
      DO 703 I=12,26
      PYTB(I,1)=27.5
  703 PYTB(I,2)=100.
      GO TO 99
   90 IMAX=1
      JMAX=1
   96 WRITE(15,580)
   84 READ(5,585)IYR,(PR(IC),IC=1,3)
      IF(IYR.EQ.0) GO TO 91
      NYR=IYR-1974
      IF(NYR.GT.IMAX) IMAX=NYR
      DO 83 IC=1,3
   83 PCAR(IC,NYR)=PR(IC)
      GO TO 84
   91 DO 82 J=IMAX,26
      DO 82 IJ=1,3
   82 PCAR(IJ,J)=PCAR(IJ,IMAX)
   89 WRITE(15,581)
   94 READ(5,586)IYR,(EC(IC),IC=1,3)
      IF(IYR.EQ.0) GO TO 95
      NYR=IYR-1974
      IF(NYR.GT.JMAX) JMAX=NYR
      DO 92 IC=1,3
   92 ECON(IC,NYR)=EC(IC)
      GO TO 94
   95 DO 93 J=JMAX,26
      DO 93 IJ=1,3
   93 ECON(IJ,J)=ECON(IJ,JMAX)
   88 WRITE(15,582)
      READ(5,500)AA
      IF(AA.EQ. YES ) GO TO 97
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      IF(AA.EQ. RNO  ) GO TO 99
      GO TO 88
   97 WRITE(15,587)
      DO 130 I=1,26
      IYR=I+1974
  130 WRITE(15,588)IYR,(PCAR(MM,I),MM=1,3),IYR,(ECON(NN,I),NN=1,3)
  131 WRITE(15,583)
      READ(5,500)AA
      IF(AA.EQ. YES ) GO TO 96
      IF(AA.EQ. RNO  ) GO TO 99
      GO TO 131
   99 WRITE(15,557)
      READ(5,500)AA
      IF(AA.EQ. YES ) GO TO 110
      IF(AA.EQ. RNO  ) GO TO 140
      GO TO 99
  110 WRITE(15,558)
      READ(5,569)AGAS,GRGAS
      PGAS(2)=AGAS
      DO 10 I=3,26
   10 PGAS(I)=PGAS(2)*(1.+GRGAS/100.)**(I-2.)
      GO TO 999
  140 WRITE(15,559)
      DO 150 I=2,26
      READ(5,570)PGAS(I)
      J=I-1
      IF(PGAS(I).EQ.0.0) GO TO 145
  150 CONTINUE
  145 DO 155 I=J,26
  155 PGAS(I)=PGAS(J)
      GO TO 999
  999 PGAS(1)=.60
      DO 156 I=1,26
  156 PGAS(I)=PGAS(I)/1.477
      RETURN
      END
      SUBROUTINE SETPR(IT,Q,PYTB,EXTX,SHNEW,APOL,CST,FEC,IMAXR,
     +IZERO,ACCT,MPGGPM)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      INTEGER EXTX(40,26)
      DIMENSION CST(3),FEC(3),SHMANU(15),SHNEW(3),AVGFE(5)
      DIMENSION PAVGM(3),FAVGM(3),PSET(5,3),FSET(5,3),PYTB(26,2)
      DIMENSION SS(5)
      DIMENSION VALFS(3),S(5,3)
      DIMENSION ACCT(30,26),DSET(5,3)
      DIMENSION APEN(3),ATAX(3)
      DIMENSION SR(3),IMAXR(26),IZERO(26)
  609 FORMAT(1X,5F10.3)
      DATA SHMANU/12.7,39.3,59.0,35.0,4.6,26.0,0.0,41.5,
     1 13.0,8.9,0.0,2.0,43.4,14.6,0.0/
      DATA EXCI/4HEXCI/
      DATA STAN/4HSTAN/
      DATA NONE/4HNONE/
      DATA EXOG/4HEXOG/
      DATA BOTH/4HBOTH/
      DATA SETX/4HSETX/
      PEN=0.0
      VALGPM=0.0
      DO 10 IC =1,3
      CALL FECOST(IC,IT,PEN,C,Q1,Q2,VALGPM)
      CST(IC)=Q1
      IXZ=5+IC*3
      ACCT(IXZ,IT)=Q1
   10 FEC(IC)=Q2
      XXXMAX=EXTX(40,IT-1)
      IF(APOL.EQ. EXCI) GO TO 50
      IF(APOL.EQ. STAN) GO TO 100
      IF(APOL.EQ. NONE) GO TO 150
      IF(APOL.EQ. EXOG) GO TO 200
      IF(APOL.EQ. BOTH) GO TO 50
      IF(APOL.EQ.SETX) GO TO 400
   50 XY=0.0
      VALGPM=350.0
      DO 65 MM=1,40
   65 XY=XY+EXTX(MM,IT-1)*EXTX(MM,IT-1)
      ACCT(10,IT)=0.
      ACCT(13,IT)=0.
      ACCT(16,IT)=0.
      IF(XY.NE.0.0) GO TO 66
      IF(APOL.EQ.BOTH) GO TO 100
      IF(APOL.EQ.SETX) GO TO 100
      GO TO 150
   66 DO 60 IC=1,3
      Z2=FEC(IC)
      MPG=Z2+0.5
      GENP1=1000000.0
      DO 70 ICONV=1,31
      I=ICONV-1
      PEN=20*I
      CALL FECOST(IC,IT,PEN,Q,Z1,Z2,VALGPM)
      M=Z2+0.5
      IF(M.GT.40) M=40
      GENP2=Z1+52853*Q/Z2+EXTX(M,IT-1)
      IF(GENP2.GT.GENP1) GO TO 70
      IBEST=I
      GENP1=GENP2
   70 CONTINUE
      PEN=20*IBEST
      CALL FECOST(IC,IT,PEN,Q,Q1,Q2,VALGPM)
      M=Q2+0.5
      IF(M.GT.40) M=40
      CST(IC)=Q1+EXTX(M,IT-1)
      IZT=7+IC*3
      ACCT(IZT,IT)=EXTX(M,IT-1)
      FEC(IC)=Q2
      ATAX(IC)=EXTX(M,IT-1)
      APEN(IC)=PEN
   60 CONTINUE
      IF(APOL.EQ. BOTH) GO TO 100
      IF(APOL.EQ.SETX) GO TO 100
      GO TO 150
  400 REBMAX=10.*(IMAXR(IT)-IZERO(IT))
      ROLD=0.0
      ACCT(17,IT)=IZERO(IT)
      ACCT(18,IT)=IMAXR(IT)
      IF(IZERO(IT).EQ.0) ACCT(19,IT)=0.0
      IF(IZERO(IT).EQ.0) GO TO 50
      JCONV=0
  350 IST=IZERO(IT)+1
      PEN=0.0
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      JCONV=JCONV+1
      DO 354 IC=1,3
      CALL FECOST(IC,IT,PEN,Q,Q1,Q2,VALGPM)
      CST(IC)=Q1
  354 FEC(IC)=Q2
      REBINC=REBMAX/(IMAXR(IT)-IZERO(IT))
      IMT=IMAXR(IT)
      REBHAR=REBINC/(1./IMT-1./(IMT+1.))
      DO 300 I=IST,IMT
      J=I-IST+1
      EXTX(I,IT-1)=-REBINC*J
      IF(MPGGPM.EQ.1) EXTX(1,IT-1)=REBHAR*(1./I-1./IZERO(IT))
  300 IF(EXTX(1,IT-1).LE.XXXMAX) EXTX(1,IT-1)=XXXMAX
      DO 302 I=IMT,40
  302 EXTX(I,IT-1)=EXTX(IMT,IT-1)
      RZ=EXTX(40,IT-1)
      IF(RZ.GT.XXXMAX-5.) GO TO 307
      REBHAR=XXXMAX/(1./IMT-1./IZERO(IT))
      REBINC=REBHAR*(1./IMT-1./(IMT+1.))
      REBMAX=REBINC*(IMAXR(IT)-IZERO(IT))
      GO TO 350
  307 CONTINUE
      GO TO 50
  305 AA=4140.8841
      IF(IZERO(IT).EQ.0) GO TO 150
      G1=CST(1)/1.612+(52853./FEC(1))*(Q/1.477)
      G2=CST(2)/1.612+(52853./FEC(2))*(Q/1.477)
      G3=CST(3)/1.612+(52853./FEC(3))*(Q/1.477)
      G1=G1*3010./2993.943
      G2=G2*3863./3839.314
      G3=G3*4883./4854.983
      A=4.1749+1.8666*1.3898*G1/AA
      B=(-3.5093*1.0966*G2)/AA
      D=-5.6428*(SHNEW(1)+0.25)*0.5
      SR(1)=1.0/(1.0+2.7183**(A+B+D))
      A=4.1749+2.0765*1.0966*G2/AA
      B=-3.545*1.3898*G1/AA
      B=B-0.2589*0.8181*G3/AA
      D=-5.6428*(SHNEW(2)+.245)*0.5
      SR(2)=1.0/(1.0+2.7183**(A+B+D))
      A=4.1749+0.4299*0.8181*G3/AA
      B=-1.8117*1.0966*G2/AA
      D=-5.6428*(SHNEW(3)+0.505)*0.5
      SR(3)=1.0/(1.0+2.7183**(A+B+D))
      SRTOT=SR(1)+SR(2)+SR(3)
      SR(3)=0.8*SR(3)+0.2*SR(3)/SRTOT
      SR(2)=(SR(2)/(SR(1)+SR(2)))*(1.-SR(3))
      SR(1)=1.-SR(2)-SR(3)
      PAYMNT=0.0
      REBATE=0.0
      DO 315 IC=1,3
      M=FEC(IC)+0.5
      PAYC=EXTX(M,IT-1)*SR(IC)
      IF(JCONV.LE.10) DAMP=0.95
      IF(PAYC.LT.0.0) REBATE=REBATE+PAYC
  315 PAYMNT=PAYMNT+PAYC
      IF(REBMAX.EQ.ROLD) GO TO 150
      ROLD=REBMAX
      QA=PAYMNT*PAYMNT
      QTEST=1.
      IF(JCONV.GT.15) QTEST=10.
      IF(JCONV.GT.20) QTEST=2.0*JCONV
      IF(JCONV.GT.25)  GO TO 150
      IF(QA.LT.QTEST) ACCT(19,IT)=EXTX(IMT,IT-1)
      IF(QA.LT.QTEST) GO TO 150
      IF(REBATE.EQ.0.0) ACCT(19,IT)=0.0
      IF(REBATE.EQ.0.0) GO TO 360
      LJ=JCONV-3*(JCONV/3)
      IF(LJ.EQ.0) DAMP=0.83
      IF(LJ.EQ.1) DAMP=0.63
      IF(LJ.EQ.2) DAMP=0.53
      IF(JCONV.GT.25) DAMP=DAMP*0.7
      IF(JCONV.GT.35) DAMP=DAMP*0.7
      IF(JCONV.GT.45) DAMP=DAMP*0.7
      WRITE(15,650) IT,JCONV,EXTX(IMT,IT-1),RESET
  650 FORMAT(2I5,I10,F10.3)
      RESET=(1.-DAMP*PAYMNT/REBATE)
      IF(RESET.EQ.0.) GO TO 353
      IF(RESET.GT.2.50) RESET=2.50
      IF(RESET.LT.0.25) RESET=0.25
      REBMAX=REBMAX*RESET
      GO TO 350
  353 PTD=REBMAX*REBMAX
      IF(PTD.GT.625.0) GO TO 377
      REBMAX=0.0
  377 REBMAX=0.25*REBMAX
      GO TO 350
  360 REBMAX=REBMAX*1.5
      GO TO 350
  100 STD=PYTB(IT,1)
      PEN=PYTB(IT,2)
      VALGPM=1./((1./(STD-0.5))-(1./(STD+0.5)))
      ACCT(4,IT)=0.0
      ACCT(5,IT)=0.0
      ACCT(6,IT)=0.0
      IF(PEN.GT.0.0) GO TO 101
      IF(APOL.EQ.SETX) GO TO 305
  101 ACCT(10,IT)=0.0
      ACCT(13,IT)=0.0
      ACCT(16,IT)=0.0
      IF(PEN.LE.0) GO TO 150
      DO 102 MANU=1,5
      DO 102 IC=1,3
      IM=(MANU-1)*3+IC
  102 S(MANU,IC)= SHNEW(IC)*SHMANU(IM)/100.
      DO 103 MANU=1,5
      XX=0.0
      DO 104 IC=1,3
  104 XX=XX+S(MANU,IC)
      DO 105 IC=1,3
  105 S(MANU,IC)=S(MANU,IC)/XX
  103 CONTINUE
      DO 110 MANU=1,5
      DO 111 ICONV=1,11
      I=ICONV-1
      AVGFE(MANU)=0.0
      DO 112 IC=1,3
      P=PEN*I/10.0
      IF(APOL.EQ. BOTH) P=P+APEN(IC)
      IF(APOL.EQ.SETX) P=P+APEN(IC)
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      CALL  FECOST(IC,IT,P,Q,Q1,Q2,VALGPM)
      P=PEN*I/10.
      PSET(MANU,IC)=Q1+P*VALGPM*(1./Q2-1./STD)
      FSET(MANU,IC)=Q2
      DSET(MANU,IC)=PSET(MANU,IC)-Q1
  112 AVGFE(MANU)=AVGFE(MANU)+S(MANU,IC)/FSET(MANU,IC)
      AVGFE(MANU)=1./AVGFE(MANU)
      IF(AVGFE(MANU).GE.STD) GO TO 115
  111 CONTINUE
  115 CONTINUE
      SS(MANU)=0.0
  110 CONTINUE
      DO 120 IC=1,3
      PAVGM(IC)=0.0
      FAVGM(IC)=0.0
      DO 121 MANU=1,5
      IM=(MANU-1)*3+IC
      SX=SHMANU(IM)/100.
      SS(MANU)=SS(MANU)+SHNEW(IC)*SX
      IZT=7+IC*3
      ACCT(IZT,IT)=ACCT(IZT,IT)+SX*DSET(MANU,IC)
      ACCT(IC+3,IT)=ACCT(IC+3,IT)+SX*DSET(MANU,IC)
      PAVGM(IC)=PAVGM(IC)+SX*PSET(MANU,IC)
  121 FAVGM(IC)=FAVGM(IC)+SX/FSET(MANU,IC)
      FAVGM(IC)=1.0/FAVGM(IC)
      CST(IC)=PAVGM(IC)
      FEC(IC)=FAVGM(IC)
      M=FEC(IC)+0.5
      IF(M.GT.40) M=40
      IZT=7+IC*3
      IF(APOL.EQ.BOTH) ACCT(IZT,IT)=ACCT(IZT,IT)+EXTX(M,IT-1)
      IF(APOL.EQ.SETX) ACCT(IZT,IT)=ACCT(IZT,IT)+EXTX(M,IT-1)
       IF(APOL.EQ.BOTH) CST(IC)=CST(IC)+EXTX(M,IT-1)
       IF(APOL.EQ.SETX) CST(IC)=CST(IC)+EXTX(M,IT-1)
  120 CONTINUE
      IF(APOL.EQ.SETX) GO TO 305
      GO TO 150
  200 DO 233 IC=1,3
      CST(IC)=PCAR(IC,IT)*1.612/1.477
  233 FEC(IC)=ECON(IC,IT)
  150 DO 234 IC=1,3
      IZT=7+IC*3
  234 ACCT(IZT-1,IT)=CST(IC)-ACCT(IZT,IT)-ACCT(IZT-2,IT)+.01
      ACCT(7,IT)=0.0
      IF(STD.EQ.0.0) GO TO 238
      DO 236 MANU=1,5
      XC=0.5*PEN*(STD-AVGFE(MANU))
      IF(XC.GT.0.0) ACCT(7,IT)=ACCT(7,IT)+XC*SS(MANU)
  236 CONTINUE
  238 CONTINUE
      RETURN
      END
      REAL FUNCTION HFN(L,K,W,N)
      DIMENSION ALPHA(12),BETA(12)
      DATA ALPHA/55.,65.,65.,11.,13.,13.,1.5,3.0,5.9,1.5,3.0,
     1 5.9/
      DATA BETA/2.1,1.65,2.1,2.0,1.85,2.2,2.40,2.35,2.35,2.4,2.35,2.35/
C
      HFN=W*ALPHA(L)*(N/10.)**BETA(L)+(1.-W)
     1 *ALPHA(K)*(N/10.)**BETA(K)
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      RETURN
      END
      SUBROUTINE FECOST(IC,IT,PEN,Q,PR,FE,VALGPM)
      DIMENSION DELPR(12),DELFE(12)
      DIMENSION BASEPR(3),BASEFE(3)
      DATA DELPR/-15.08,-40.68,-64.89,380.,450.,485.,575.,605.,
     1 600.,835.,865.,860./
      DATA DELFE/1.3,1.2,.9,.8,1.5,1.9,1.4,.5,1.,1.5,1.3,1.9/
C
      DATA BASEPR/3330.,3794.,4993./
      DATA BASEFE/22.54,16.8,13.79/
      J=(IT-2)/5
      JW=(IT-1-J*5)
      W=JW/5.
      W=1.-W
      JJ=J
      IF(JJ.GT.3) JJ=3
      II=JJ+1
      IF(II.GT.3) II=3
      IF(IT.LE.2) II=0
      K=3*II+IC
      L=3*JJ+IC
      FE=W*DELFE(L)+(1.-W)*DELFE(K)+BASEFE(IC)
      FEO=FE
      X=100000.
      DO 100 IN=1,1000
      FE=FE+0.1
      VV=(1./FEO)-(1./FE)
      Y=HFN(L,K,W,IN)-VV*PEN*VALGPM+52853*W/FE
      IF(Y.LE.X) GO TO 100
      M=IN-1
      FE=FE-0.1
      PR=W*DELPR(L)+(1.-W)*DELPR(K)+BASEPR(IC)
      PR=PR+HFN(L,K,W,M)
      GO TO 99
  100 X=Y
   99 RETURN
      END
      BLOCK DATA
      COMMON/BLOCK1/PGAS(26),POP(26),DISINC(26),CPI(26)
      COMMON/BLOCK2/PCAR(3,26),ECON(3,26),INCOME(10,26)
      COMMON/BLOCK5/OPCALL(26),OPCARS(26),VMT(26),SRATE(20),
     1SCRAP(3,26)
      COMMON/BLOCK6/FLEET(3,20),FUELEC(3,20),RFLEET(3,20)
      COMMON/BLOCK9/NFUELE(3,20)
      COMMON/BLOCK7/MILES(26),FECON(26),UNEMPR(26)
      COMMON/BLOCK8/FFUEL(26),APRICE(26),TARGET(26),TSCRAP(26)
      DIMENSION QFLEET(42),QFUEL(42)
      EQUIVALENCE (FLEET(1,1),QFLEET(1)),(FUELEC(1,1),QFUEL(1))
      DOUBLE PRECISION TSCRAP,SALES,POP,OPCARS,TARGET,SCRAP,
     1FLEET,RFLEET,QFLEET
      DATA POP/69840530.,70976148.,72130232.,73303082.,
     174495002.,75706303.,76937300.,78188313.,79459668.,
     280751695.,82064731.,83399117.,84755200.,86133334.,
     387533876.,88957191.,90403650.,91873628.,93367509.,
     494885680.,96428537.,97996481.,99589919.,101209268.,
     5102854947.,104527368./
      DATA DISINC/10074.,10418.,10773.,11140.,11520.,11913.,
     112108.,12306.,12508.,12713.,12921.,13160.,13404.,13652.,
     213905.,14163.,14375.,14591.,14809.,15037.,15258.,15486.,
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315718.,15954.,16194.,16437./
 DATA TARGET/91062400.,94501650.,98070800.,101774750.,
1105618590.,109607600.,111897800.,114235850.,116622750.,
2119059520.,121547200.,121883480.,126264670.,128691630.,
3131165240.,133686390.,137323156.,140459922.,144596688.,
4148233454.,151370220.,155506986.,159143752.,162780518.,
5166417284.,170054049./
 DATA UNEMPR/8.9,7.5,6.1,23*4.7/
 DATA SRATE/0.0020,0.0055,0.0105,0.0201,0.0347,0.0602,
10.1016,0.1570,0.2146,0.2600,0.2889,0.3015,0.3000,0.2917/
 DATA QFLEET/2962430.,1287421.,3999850.,2750352.,1337311.,
14821804.,3401495.,1158513.,6831469.,3360959.,801171.,
26256219.,2908020.,1403673.,5276239.,2087318.,1762746.,
34008814.,1601107.,1803422.,4837065.,1287753.,2027511.,
44060185.,1086397.,1580415.,2859115.,1085556.,1077700.,
52458098.,888392.,729469.,1961478.,670078.,366559.,1167569.,
6426137.,284332.,732108.,728542.,594130.,1501008./
 DATA QFUEL/25.39,19.81,14.51,22.96,17.37,12.2,24.0,17.6,
112.31,23.21,16.69,12.81,23.94,16.10,13.18,22.46,17.48,
213.40,22.67,17.18,13.38,22.36,17.31,13.68,24.17,17.31,
313.96,18.31,17.11,13.90,22.18,17.29,14.24,22.03,17.82,
414.58,21.38,16.28,13.82,21.38,16.28,13.82/
 END
END OF FILE
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FOOTNOTES

1. There is some debate about the declining relationship between fuel economy and vehicle age. In his review of the topic of fuel economy, Murrell (1980) notes that, under constant operating conditions, there is a small and positive relationship between odometer mileage and fuel economy. However, when vehicle lifetime usage patterns (vehicle travel generally decreases with age of vehicle) are considered, "relative mpg rises initially, reaches its peak in one to two years, and declines thereafter" (p. 236). (Relative mpg relates the particular mpg to a base mileage mpg that is estimated after a break-in period.) In their new-car operating cost study, the Hertz Corporation (1979) allows for a "slight reduction" in fuel efficiency over time, even under the assumption of "full, complete, and proper maintenance." That relationship between fuel economy and vehicle age is based on Hertz's proprietary cost data and estimates.

2. The Federal Highway Administration data series on vehicle operating costs contains cost estimates for standard, compact and subcompact automobiles, but not all three for each year. Only standard-size car cost estimates are provided by Cope and Liston (1968) and Cope and Gauthier (1970). The later reports (Liston and Gauthier 1972; Liston and Sherrer 1974; and Liston and Aiken 1976) provide cost estimates for all three size classes of cars. These costs are based on Baltimore area prices. The cost estimates do not include finance charges, nor are the costs discounted to obtain a present value. The costs are only those expected to be incurred during a 100,000 mile, 10 year life of the car. To perform the correlation, the HSRI staff pooled the 1968, 1970, 1972, 1974 and 1976 observations. This produced 11 observations. The correlation between gasoline costs and the sum of all operating costs excluding gasoline costs is 0.902. The correlation between the logs of those 2 data series is slightly lower, 0.894.

3. The fuel economy/cost relationships used in the original version of the model were modified for the later versions of the model to account for the increasing impact of diesel engines on fuel economy.

4. The range ($0-$600) of the potential add-on costs does not imply that the model cannot simulate negative taxes (rebates). This is because the relationship between costs and fuel economy ratings is determined in such a way that the rate at which costs are minimized depends on the absolute value of the potential policy add-on costs.

5. Another problem is that an approximation value (VALGPM) is used to scale the units in which additional costs are calculated in the generalized-cost-minimizing algorithm. For the Excise Tax/Rebate option, this value is set to \$350, and corresponds to a fuel economy rating of 18.7 mpg during the additional cost calculations. This is an inflexible and questionable assumption. A better assumption would be to set the value of VALGPM so that this fuel economy rating is the rating at which excise taxes are zero (which varies with the user's specification of excise taxes and rebates). For both options (Standard/Penalty and Excise Tax/Rebate) this fuel economy rating is best set at the level of the standard. These changes have been made in later versions of the Faucett model program.

6. The appropriate test to determine if an additional sample of m observations (where m is less than the number of parameters, k) may be considered to come from the same population is as follows (Johnston 1972, p. 207):

$$F = \frac{(e'e - e_1'e_1)/M}{e_1'e(n - k)} \sim F(m, n - k)$$

where

$e_i'e_i$ is the residual sum of squares from the least-squares regression over the first n observations ($n > k$)

$e'e$ is the residual sum of squares from the least-sqauares regression over the n+m observations.

The 5% and 1% points for the distribution of F(1, 10) are 4.96 and 10.04, respectively. The test of the omission of 1968 yielded an F(1, 10) = 0.2235. The hypothesis that the 1968 observation is from the same population as the 1960-1967, 1969-1973 observations cannot be rejected at the 95% level of confidence. The test of the addition of 1973 yielded an F(1,10) = 11.1. The hypothesis that the 1973 observation is from the same population as the 1960-1972 observations is rejected at the 99% level of confidence.

7. For further evidence concerning the problems of this type of stock-adjustment approach, see the analysis of the Wharton E.F.A. Automobile Demand Model by Golomb, Luckey, Saalberg, Richardson, and Joscelyn (1979). Wharton's time-series application of a cross-sectionally estimated desired (target) stock equation required major revisions to the calculated stock time series. Those revisions to the historical stock time-series were performed to improve the explanatory power of the new-car-sales equation. That the Wharton desired-stock equation with its relatively numerous demographic and economic variables produced a stock time-series requiring substantial revision, suggests that such a cross-sectionally estimated equation cannot simply be applied to time series data.

8. There are additional problems with interpreting b_1 as a price elasticity if relevant explanatory variables are omitted from the equation. If these variables are correlated with the price variable, b_1 will be biased.

9. As an experiment, one-period lagged values of the gap were added to the new-car-sales equation and the coefficients were reestimated. The results of this experiment are (standard errors in parentheses):

$$\ln(N_t) = \underset{(1.49)}{7.98} + \underset{(0.18)}{0.40} \ln O_t - \underset{(0.21)}{0.56} \ln O_{t-1} - \underset{(0.43)}{2.34} \ln A_t^*.$$

This formulation improves the statistical significance of each variable and the R^2s and F statistics increase to 0.87 and 22.64 respectively. Both current and lagged gaps are statistically significant at the 5% level. The negative coefficient for lagged gap is not uncommon in distributed lag models of cyclical economic time series. One interpretation of these experiments is that in this formulation the adjustment process is larger than one period. Also, the addition of lagged gaps improves the statistical fit of the equation and indicates that changes in unit sales are more sensitive to changes in average generalized price. Further experiments using one- and two-period lags confirmed these results. Finally, the addition of a third-period lag added little to the explanatory power of the equation.

10. Dr. Daniel H. Hill of The University of Michigan Institute for Social Research pointed out to the HSRI staff that the semilog specification is considered by economic theorists to be inappropriate for demand estimation because no known theoretically plausible preference ordering leads to a semilog demand function. The HSRI staff has not determined the extent to which this creates problems for the model, however, the semilog specification does not, on cursory examination, appear to be an approximation to consumer behavior over the relevant range.

11. Also pointed out to the HSRI staff by Dr. Daniel H. Hill.

12. The historical period simulation was based substantially on the data used to estimate the equations in the Demand Block. Although 1974 and 1975 data were used to estimate the VMT equation, other data were not available. This problem is exemplified by the price and fuel economy data constructed by JFA. In simulations over the future period, the model authors chose 1976 as the initial year and consequently did not include 1974 and 1975 exogeous data in either the computer program or the documentation. Examples of the required data are target stock, baseline vehicle prices, and baseline fuel economies.

13. These sources are:

U.S. Department of Transportation and U.S. Environmental Protection Agency. 1974. Potential for motor vehicle fuel economy improvements. Report to Congress.

Southwest Research Institute. 1974. Technological improvements to automobile fuel consumption. Prepared for the U.S. Department of Transportation and the U.S. Environmental Protection Agency. Report no. DOT-TSC-OST-74-39.

Arthur D. Little, Inc. 1974. A study of technological improvements in autobmobile fuel consumption. Prepared for the U.S. Department of Transportation and the U.S. Environmental Protection Agency. Report no. DOT-TSC-OST-74-40.

Hittman Associates Inc. 1974. A study of industry responses to policy measures designed to improve automobile fuel economy. Prepared for the Council on Environmental Quality, U.S. Department of the Interior, U.S. Department of Transportation, and the U.S. Environmental Protection Agency. Report no. HIT-571.

14. In the DL2 version of the Faucett model, the generalized price minimizing algorithm uses fuel economy standards and penalties modified to be compatible with FE. The modifications reflect the relationships used to estimate the EPA and OTR fuel economies. In the DL2-76 version computer program, this occurs as follows:

STAN = 1.14(2.34 + .74 x STANEPCA)

PEN = PENEPCA x STANEPCA/1.14(2.32 + .74 x STANEPCA)

where

STAN = fuel economy standard in terms of FE

STANEPCA = fuel economy standard as set forth by EPCA (in EPA terms)

PEN = penalty in terms of FE

PENEPCA = penalty as set forth by EPCA (in EPA terms)

The DL2-77 version computer program also contains modifications for the appropriate years:

STAN = 1.14(2.98 + .65 x STANEPCA)

PEN = PENEPCA x STANEPCA/1.14(2.98 + .65 x STANEPCA)

Note that these modifications are for use under the Standard/Penalty option only; the Excise Tax/Rebate option was not modified to reflect EPA-OTR differences.

15. Actual implies those retail prices and EPA fuel economies used to estimate the model's demand side equations. See Sections 5.12 and 5.13 for further discussion.

15. A related statistical issue is the impact of the rounding errors in the data used in estimation on the equations and the resulting standard error statistics. In general, ordinary least squares produces inconsistent estimates of the equation parameters when there is measurement error in the dependent variables. Appropriate estimation techniques in this situation are instrumental variables or weighted regression (Kmenta 1971, pp. 307-322).

17. It might be helpful to note that the test statistic for the hypothesis that $MSE_F = MSE_T$ was a specific example of a more general test:

$$T = (S_1^2 - \Theta S_2^2)\ \sqrt{n-2}\ /\ \sqrt{4S_1^2\ S_2^2\ \Theta(1-r^2)}$$

Here all of the symbols are defined as in the text except that $\Theta = \sigma_1^2/\sigma_2^2$. Under the null hypothesis $\Theta = 1$ and the formula reported in the text results. The analogy between this test and the ones for correlated means is clear. The earliest references to hypotheses test concerning variation using this technique seem to be Morgan (1939) and Pitman (1939).

18. The cost function parameters used in the Faucett model were taken from a study performed by Hittman Associates (1976). JFA has documented the source of the values of the parameters used in the original version of the model (Jack Faucett Associates 1976b). However, the values of the β parameter in the original version of the model differ from those in all other versions. The derivation of the β values for those versions other than the original is not documented.

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